"*On a new form of Railway Chairs and improved Fastenings.*" By Charles May, Assoc. Inst. C.E.

At the suggestion of Mr. Cubitt, V.P., a series of experiments was instituted at the works of Messrs. J. R. & A. Ransome, of Ipswich, for the purpose of determining the most advantageous form of the chairs, and most secure mode of fastening them upon the sleepers of the South Eastern Railway. The result of these experiments has been to produce the cast iron chairs, and wooden treenails as fastenings, which were exhibited at the meeting, and described by the author.

In the event of a chair breaking, it is desirable that the fracture should occur in such a manner as to prevent any of the loose pieces being thrown into situations where they would interfere with the passing trains; to ensure this, the weakest part of these chairs is across the seat—they are, however, stronger in that part than any other chair now in use. In order to ascertain the proper relative proportion between the strength of the jaw and that of the seat, many experiments were made by varying the forms, and wedging the chairs, until they broke, sometimes in one and at other times in the other part; it was then easy to add so much strength to the jaw as would, without waste of metal, cause the fracture to take place invariably across the seat.

For the purpose of ensuring perfect accuracy of form, with a smooth internal surface, so that wedges of a uniform shape and size might be used, the chairs are cast upon metal cores; the joint-chair has an upper piece, overlapping the wedge, to keep the rail in a perpendicular position, and to prevent the end of it from being thrown up or forced away laterally, if the wedge should accidentally be removed. This form of chair was originally planned by Mr. John Harris, the engineer of the Stockton and Darlington railway, where it has been in use above twelve months, giving perfect satisfaction. The rail is so placed in the intermediate chairs, that when it receives the pressure of the wedge, it is held firmly down on the seat, against the lower part of the jaw, and at the upper part against a slightly projecting rib, which bears against the neck of the rail.

The holes for the fastenings are so arranged as not to be in the same line; a large portion of the current expense of the maintenance of way on railroads arising from replacing the sleepers which have been split by the spikes being driven in the same line in the grain of the wood.

The mode of fastening adopted in this case is, to use treenails of dry English oak, compressed into two-thirds of their original bulk, by being forced under a fly press, into metal tubes, in which they are placed in a chamber heated to about 180°, where they remain 16 hours: the pressure upon the body of the treenail (the head not being compressed) is sufficient to materially increase the specific gravity without injuring the fibre, or diminishing the strength of the wood, and it retains the form thus given until it has been driven into a damp sleeper, when the expansion is sufficient to fix it firmly.

The ordinary mode of fastening chairs with iron spikes has been found disadvantageous, because one blow too many causes a reaction, and frequently loosens them, whilst treenails may be driven to any depth, and the heads subsequently split with small wedges if necessary.

Rails should be 'keyed-up' so tightly as to ensure security, still leaving a large amount of surplus strength in the chair to resist any shock to which they may be exposed:—with wedges of varying dimensions, the chairs, which are frequently of unequal quality, and carelessly cast, are liable to be brought nearly to the breaking point, and to give way as soon as they are subjected to any additional strain. This has been avoided in the chairs and wedges under consideration, by giving them exact uniformity of dimensions.

The wedges adopted are of English oak, cut out of square timber, so formed as to drive equally well with either side to the rail, and compressed into five-sixths of their bulk, by the same process as is used for the treenails.

Many advantages will result from this form of chair and wedge, with the treenails for fastening; the time occupied in laying the rails is diminished; the holes for the fastenings may be bored in the sleepers by machinery, at a diminished cost, and greater accuracy of gauge obtained at the same time; the required inclination of the rail being given in the chair, no cutting away of the sleeper is necessary; the sole of the chair is fixed horizontally upon the surface of the sleeper, and all of them may be placed accurately in the same plane, thus bringing to bear upon the hitherto roughly executed details of railway engineering, those mechanical contrivances by which the cost is diminished, whilst the dependance upon the skill and attention of the workmen is avoided; at the same time insuring the accuracy of the line, upon which so large a portion of the economy of working a railway depends.

Specimens of the chairs, wedges, and treenails, accompanied this communication.

Mr. Cubitt observed, that two modes of preparing treenails had been hitherto adopted: one was, by forcing the wood through a steel die, in which case neither the form nor the diminished bulk was preserved, as on leaving the die it swelled nearly to its original size. The other was by passing the wood between rollers: this latter process had been found to cause permanent injury to the fibre of the wood, by crushing the capillary tubes, and consequently depriving it of much of its strength. To the mode of preparing the treenails under consideration, neither of these objections existed. He anticipated many advantages from the use of this form of chair, wedge, and fastening. They would certainly be cheaper even in the first cost than the ordinary chairs, fastened down by iron spikes. The usual calculation for a double line of rail was 880*l*. per mile for the chairs, wedges, and spikes. The cost of these chairs, with the compressed wedges and treenails, would be 786*l*. per mile. The price of the compressed treenails for railway purposes would be 5*l*. 10*s*. per thousand; that of iron spikes was 6*l*. 5*s*. per thousand. The wedges 2½ inches square, cost 2*l*. per thousand for each inch of their length, so that those for the joint-chairs, which are 8 inches long, average 16*l*., and those for the intermediate chairs, of 6 inches long, cost about 12*l*. per thousand. Each joint-chair, with wedge and treenails, costs 2*s*. 10*d*.; and the intermediate ones, with their appendages, 2*s*. 1*d*. each.

One great cause of expense on railways was the fracture of the chairs during the laying. He knew an instance where in a length of 20 miles of railway 180 tons of chairs had been broken, either by wedging or in driving down the spikes. This was in the ratio of one chair in ten. In the ordinary mode the oak wedges are driven home by a 14 lb. sledge hammer, whereas with the new chair the compressed wedges and trenails are driven by a light wooden mallet.

Mr. Pim remarked that the wood fastenings used for the chairs on the Dublin and Kingston Railway had been compressed by rolling. He considered the present plan much superior.

Mr. Vignoles corroborated the statement of the cost of chairs of the ordinary construction. On the railways of the north of England oak treenails had been used as fastenings for a considerable period. The plan now proposed presented many advantages, not only in the construction of the chairs, which appeared well designed and excellently cast, but in the form and mode of preparation of both the wedges and the treenails.

In answer to a question from the President, whether the compressed treenails could be applied with advantage in ship building—Mr. Mills was of opinion they could be so employed, provided the fibre was not injured by the process. He believed that sound wooden treenails were better fastenings for ships than iron bolts, and quite as good as copper, whilst by their use the expense was materially reduced. Turned treenails of locust wood were at present preferred to all other kinds.

Mr. S. Seaward understood that, at the Royal Dockyards, treenails which were crooked as much as three times their own diameter were preferred to straight ones. He believed that the late Mr. H. Maudslay had constructed some machinery expressly for turning them crooked.

Mr. Hawkins remarked that the treenails were frequently crooked, because the rending caused them to follow the direction of the grain of the timber. Twenty-two years since, Mr. Annesley took out a patent for building ships without ribs. He used for fastenings, treenails compressed by being forced through steel dies, just before driving them into the planks, so that their expansion fixed them firmly in the planking. He built a vessel of very light construction, the sides of which were formed of five thicknesses of ¾-inch boards, held together by compressed treenails, without any ribs. It had proved very stiff and durable.

In reply to a question from Mr. Vignoles, whether the swelling of the compressed treenails in the ribs would not have the effect of preventing the possibility of the "butt end" of a plank starting—Mr. Mills believed that such an event was of rare occurrence; treenails were subjected more to a lateral strain; they were frequently "backed out" after the planks had been fitted into their places; when the latter were properly bent they retained their shape, and had no tendency to spring out.

Mr. S. Seaward, in support of the opinion that leaks did occur from planks starting, instanced the "Marquis of Huntly," East Indiaman, which was injured in the Downs, by a collision with another vessel; she proceeded on her way to China, but during the whole voyage out and home forty extra men were employed at the pumps. On being taken into dock, it was found that the "butt end" of one of the bow planks had started for 8 or 9 feet in length, and nothing but constant labour and attention had kept the ship afloat, at an expense of 7,000*l*. to the owners.

March 9.—The President in the Chair.

The following were balloted for and duly elected: Joel Spiller, as a Member; John Pope, as a Graduate; Thomas Routledge and Frederick Taylor, as Associates.

"*Description of a Bridge for a Railway crossing above a Turnpike Road, where the depth between the soffit of the Bridge and the surface of the Rails is limited, to twenty-one inches.*" By John Pope, Grad. Inst. C.E.

This bridge was designed by Mr. W. Cubitt, V.P., to meet the conditions of a clause in a Railway Bill, which required that there should be a clear width of opening for headway through the bridge in every part, 30 feet wide by 20 feet high, whilst at the same time the height of the embankment limited the space between the under side of the bridge and the surface of the rails to 21 inches.

The railway is carried on three cast iron girders, each 3 feet deep at the centre, diminishing to 6 inches at each end, with a bearing of 2 feet on cast iron wall-plates, supported by brickwork abutments. The flanches of the girders are 8 inches wide, and the metal every where 2 inches thick. Balks of Memel timber, 12 inches square, are laid transversely, close jointed, their ends bearing upon the flanches of the girders: on these timbers the chairs are fixed, and the rails are laid. The whole depth employed is—

The flanch of the girder - -	2 inches
Thickness of timber balks - -	12 "
Depth of the rail and chair - -	6¼ "
	20¼

One of the girders on each side supports the parapet wall in which it is completely encased, and being faced with cut stone, assumes the appearance of a flat camber arch, 3 feet in depth.

A detailed drawing, showing minutely the construction, accompanied this communication.

ARCHITECTURAL SOCIETY.

Conversazioné held Tuesday evening, the 1st of June, 1841, William Tite, Esq., President in the Chair.

After the report of the proceedings of the Society during the session was read, the President delivered a very interesting lecture, "*On the researches made in Egypt, at the expense and under the authority of the Tuscan Government.*" By Signor Rosillini. The lecture was illustrated by a variety of drawings, models, and valuable engravings, which very considerably enhanced its interest.

At the completion of the lecture the President announced the agreeable duty which he had to perform, in the distribution of the prizes which had been awarded by the Society for competition during the past session; at the same time he expressed his regret that the students had not been more active in the other classes of competition, and stated that although prizes had been offered by the Society for competition in the class of original design, in the class of measured drawings from a public building, and also for the best fairly transcribed notes of the Professor's lectures, yet it became his painful duty to state that no competition whatever had been attempted in either of these classes; neither was there any competition for the prize offered for the best drawing of the human figure from a plaster cast in the possession of the Society. Having made these observations, the President proceeded to the distribution of the two prizes which had been awarded, viz., to Mr. Arthur Johnson, for the greatest number of the most approved sketches from subjects given by the Architectural Society during the session 1840 and 1841; and to Mr. Frederick Johnstone, for having produced the best drawing from a plaster-cast in the possession of the Architectural Society, session 1840 and 1841. The President called the attention of the meeting to some specimens of a patent which had been obtained for uniting lead and other metals without solder, which he was of opinion was worth the consideration of persons connected with building. He then announced that the business of the meeting, and of the session was concluded, and in so doing directed the attention of the visitors and other gentlemen present to the various specimens of art contributed for the evening's entertainment; among which was a very beautiful drawing, being a representation of the shield to be presented to Lord Eglinton, in commemoration of the late tournament held under his superintendance, both the design and drawing were by Mr. Henry Nixon. Also a newly invented ball-cock patented by Mr. Henry Abraham, the architect; likewise a cast in bronze of an elaborately chased Roman vase, together with sundry specimens of Roman tesselated pavement.

There was also exhibited a very beautiful model in plaster of Mr. Tite's (the President) portico of the New Royal Exchange, as approved and decided by the Gresham Committee, to be erected—it elicited considerable praise and attraction. There was another model of the New Church now erecting at Muswell Hill, under the direction of William Barnes, Esq. Also sundry models by Mr. Samuel Nixon, as well as numerous drawings by Henry Nixon, Clayton, G. B. Moore, Punnett, Meredith, William Barnes, G. Mair, William Grellier, William Nunn, &c. &c. The meeting was numerously attended, and was favoured by the presence of many of the leading and most scientific men of the day.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

June 7.—A paper was read by the Rev. R. Burgess, Hon. Member, on the Roman temples. Mr. Burgess traced, in a most interesting and entertaining narrative, the history of the temples of antiquity, from the rays encircling the heads of the heathen deities, originally applied as a protection to the heads of their statues, and the niches in which they were subsequently ensconced, down to the gorgeous edifices of the Roman empire.

June 21.—Mr. T. L. Donaldson, Fellow, read a description of the column erected at Petersburg in honour of the late Emperor Alexander. The construction of this monument rivals that of the best ages of antiquity. The shaft is monolithic, of polished granite, 84 feet in length. The pedestal is also a single block of the same material, and so carefully has the durability of the work been considered, that two vast masses were successively rejected after they had been extricated from the quarry as not being sufficiently perfect. Possessed as we are in Great Britain of granite quarries capable of supplying stones of almost unlimited dimensions, it is to be regretted that such an example should be lost upon the directors of our public works. Unfortunately the example is likely to excite nothing but feelings of horror and contempt for so outrageous a dereliction of the principles of economy!

A paper was afterwards read on the open roofs of the middle ages, by T. Morris, Esq.,—many examples were exhibited and described. It appeared to be the general opinion of the meeting, that the scientific skill displayed in these beautiful and picturesque combinations of timber work has been greatly over-rated. Some have signally failed, as at Eltham, while in others, as at Westminster Hall, the principle resolves itself, on examination, into the simplest elements of roofing. The durability of these structures seems rather due to the mechanical construction of the carpentry, in which they are worthy of the greatest admiration.

MESSRS. COOKE AND WHEATSTONE'S ELECTRIC TELEGRAPH.

(From the Railway Times.)

We have given many occasional notices of this admirable invention—of its adoption on the Great Western and Blackwall Railways, and its surprising performances in both instances—but it still remains to us to lay before our readers such a detailed account of the apparatus as may enable them to comprehend fully the mode of its operation, and to estimate duly its great practical efficiency. We cannot help thinking that it must be owing in a great measure to a prevailing paucity of information on the subject of the invention, that it is not making its way more rapidly into use, and believe we shall render good service to the railway interest by doing our best to make its value more clearly, distinctly and generally known. For the following descriptive details, and the numerous engravings by which they are illustrated, we are indebted partly to the evidence given by Professor Wheatstone before the Select Committee of the House of Commons on Railways, and partly to a set of drawings with explanatory letter-press recently published by the Professor's managing partner in the invention, Mr. Cooke. Some doubts it will be recollected were raised respecting the proportions in which Messrs. Wheatstone and Cooke divided between them the merit of the invention; but these doubts have been for ever removed by the statement on the subject which we published three or four weeks ago, drawn up at the mutual request, and (we believe) to the satisfaction, of these gentlemen, by their friends Sir I. Brunel and Professor Daniell.

Professor Wheatstone having been requested by the Committee of the House of Commons to explain to them the mode in which he proposed to communicate intelligence between two distant points, made the following answer:—

I have here a copy of the drawing of the specification to the first patent taken out by myself and Mr. Cooke; in all essential particulars, the instrument here represented resembles the one at the Great Western Railway. Here is what may be called a dial (see Fig. 1,) with five vertical magnetic needles. Upon this dial 20 letters of the alphabet are marked, and the various letters are indicated by the mutual convergence of two needles when they are caused to move; if the first needle turns to the right and the second to the left, H is indicated. If the first needle deviate to the right, and the fourth to the left, then B is indicated; if the same needles converge downwards, then V is pointed to. These magnetic needles are acted upon by electrical currents, passing through coils of wire placed immediately behind them; here is the representation of one of those coils, with the position of the magnetic needle with respect to it (Fig. 6). Each of the coils forms a portion of a communicating wire, which may extend to any distance whatever; these wires, at their termination, are connected with an apparatus, which may be called a communicator, (Fig. 1,) because by means of it the signals are communicated; it consists of five longitudinal and two transverse metal bars, fixed in a wooden frame; the latter are united to the two poles of a voltaic battery, and, in the ordinary condition of the instrument, have no metallic communication with the longitudinal bars, which are each immediately connected with a different wire of the line; on each of these longitudinal bars two stops are placed, forming together two parallel rows. When a stop of the upper row is pressed down, the bar upon which it is placed forms a metallic communication with the transverse bar below it, which is connected with one of the poles of the battery; and when one of the stops of the lower row is touched, another of the longitudinal bars forms a metallic communication with the other pole of the voltaic battery, and the current flows through the two wires connected with the longitudinal bars, to whatever distance they may be extended, passing up one and down the other, provided they be connected together at their opposite extremities, and affecting magnetic needles placed before the coils which are interposed in the circuit, there must be a similar complete apparatus at every different station.

"There is another very essential part of the apparatus I wish to mention, which is, the means we have of ringing a bell before the communication begins, in order to call the attention of the observer. The general principle of the alarum is this; to the detent of an alarum, on the ordinary construction of a clock alarum, a piece of soft iron is fixed, and opposite to it there is a bar of soft iron bent to the form of a horse-shoe; round this bent bar, wire, covered with silk, is wound, forming numerous coils; it is a property of soft iron to become powerfully magnetic when an electric current passes through a coil thus surrounding it. When the horse-shoe bar thus becomes magnetic, it therefore attracts the detent, and the bell immediately rings; when the current ceases the magnetic power ceases also, and the bell

Fig. 1.—Original Electric Telegraph.

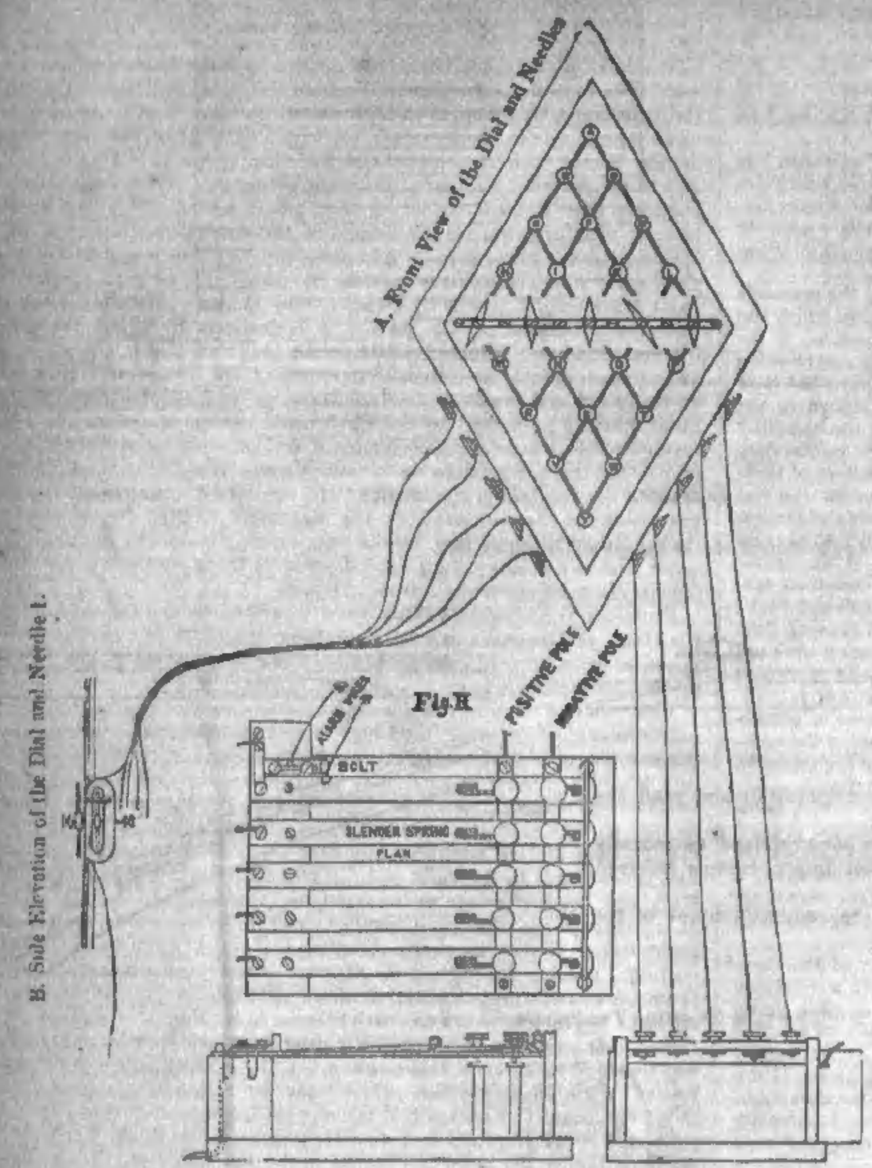
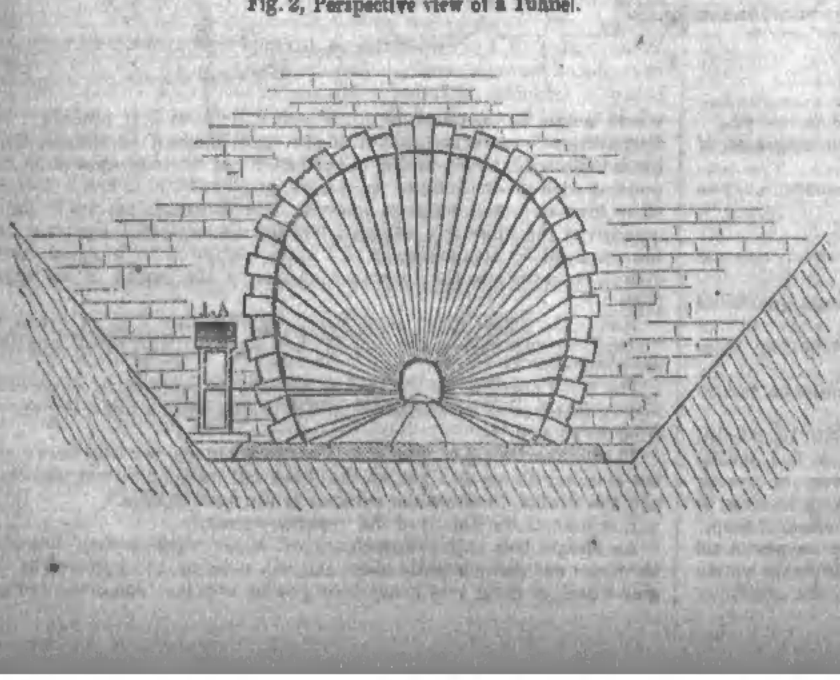


Fig. 2, Perspective view of a Tunnel.



discontinues to ring. There are several other contrivances made to effect this purpose. Some other arrangements there are to which Mr. Cooke has particularly directed his attention, relating to the means of establishing communications at intermediate parts of the line where no fixed stations exist. To effect this, posts are placed at every quarter of a mile along the line, for the purpose of establishing a temporary communication with either of the adjacent stations; the guard of a train may thus carry with him a portable instrument, by means of which he can send up a message to a station either way, whenever it may be required. The wires are kept insulated from each other by a mixture of cotton and india rubber, which is a very good insulating material; then these prepared wires are all passed, with certain precautions, through an iron tube, which in some parts of the line is buried beneath the ground, and in other parts of the line is raised above it."

Lord Granville Somerset put this case:—"Suppose the Great Western Railway were completed between London and Bristol, do you contemplate the possibility of carrying your telegraph through the whole way, so as to signify from London to Bristol any thing you wish to communicate, and *vice versa* from Bristol to London?"—Professor Wheatstone replied, "The experiment has not been tried, but I have every reason to believe that it can be done. One very important circumstance I have ascertained is the little power requisite to produce this effect; it was formerly thought, that to send a current to any considerable extent very strong batteries must be employed, but in fact a very weak battery is sufficient, provided only it consist of a number of elements proportionate to the distance. So far as my experiments have gone, I think I should be able to effect a telegraphic communication between Bristol and London. Possibly several stations might be required, but, at any rate, the stations may be at far greater distances from each other than would be required for any ordinary system of telegraphs; my opinion is, that the intermediate stations will not be required."

Mr. Loch asked whether there was any appreciable loss of time in making a communication from the Paddington station to the extremity of the line to which the telegraph is now carried? Professor Wheatstone: "From some experiments I made some years ago, published in the *Philosophical Transactions*, when I first turned my attention to the possibility of effecting telegraphic communications, I ascertained that electricity travelled through a copper wire at the rate of about 200,000 miles in a second; consequently there is no appreciable time lost in the communication of the electrical effect; the only time that would be lost would be at relay stations, if they were necessary."

Chairman: "Could you communicate from Dover to Calais in that way?—I think it perfectly practicable."

Professor W. added the following observations:

"An electrical telegraph offers a great many advantages over an ordinary telegraph; it will work day and night, but an ordinary telegraph will act only during day; it will also work in all states of weather, an ordinary telegraph can only work in fine weather. There are a great number of days in the year in which no communication can be given by an ordinary telegraph, and besides, a great many communications are stopped before they can be finished, on account of changes in the state of the atmosphere. No inconveniences of this kind would attend the electrical telegraph. Another advantage is, that the expense of the separate stations is by no means comparable to that of the ordinary telegraph; no look-out men are required, and the apparatus may be worked in any room where there are persons to attend to it. There is another advantage the electric possesses over the

ordinary telegraph, viz. the rapidity with which the signals may be made to follow each other. Thirty signals may be conveniently made in a minute; that number cannot be made by the ordinary telegraph. There is one thing I will take the opportunity to mention—I have been confining the attention of the Committee to the telegraph now working on the Great Western Railway, but having lately occupied myself in carrying into effect numerous improvements which have suggested themselves to me, I have, conjointly with Mr. Cooke, who has turned his attention greatly to the same subject, obtained a new patent for a telegraphic arrangement, which I think will present very great advantages over that which at present exists. It can be applied without entailing any additional expense of consequence to the line now laid down, it will only be necessary to substitute the new for the former instruments. This new apparatus requires only a single pair of wires to effect all which the present one does with five, so that three independent telegraphs may be immediately placed on the line of the Great Western; it presents in the same place all the letters of the alphabet according to any order of succession, and the apparatus is so extremely simple, that any person, without any previous acquaintance with it, can send a communication and read the answer."

Fig. 3, Longitudinal view of a Tunnel.

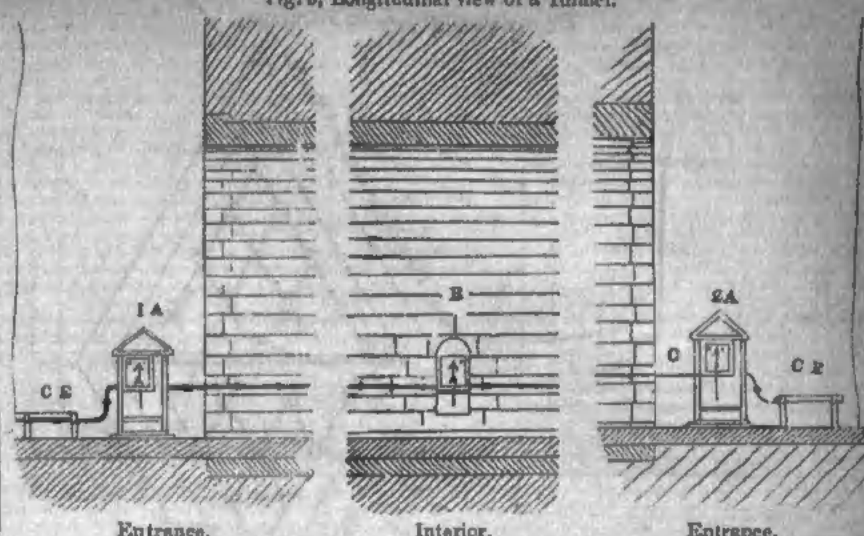
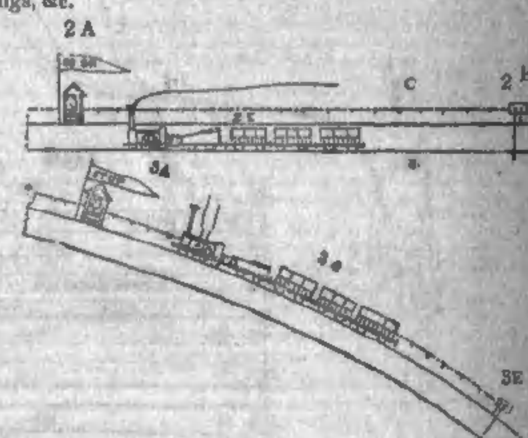


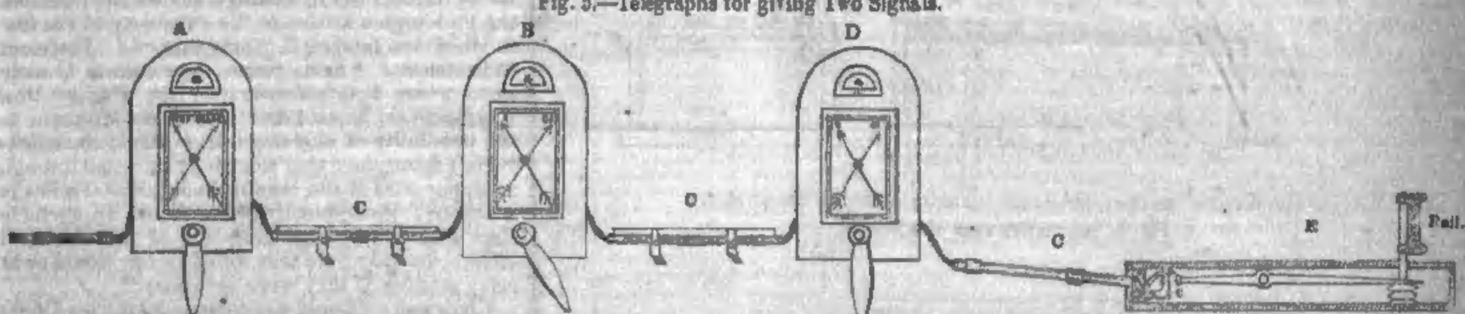
Fig. 4.—Application of the Telegraph to Crossings, &c.



The drawings and letter-press description to which we have referred as recently published by Mr. Cooke, furnish (we presume) the further improvements referred to by Professor Wheatstone in the preceding evidence.

The annexed engravings (Figs. 2 to 11, inclusive,) are reduced copies of the drawings, and subjoined is Mr. Cooke's explanation.

Fig. 5.—Telegraphs for giving Two Signals.



Figs. 2 and 3 show the application of the electric telegraph to tunnels.

1 A, 2 A. Telegraphs fixed in policemen's boxes near the entrances of tunnels.

B. Intermediate telegraph near a shaft within a tunnel, always ready to work with 1 A, 2 A, in case of need.

C. Protecting tube for conducting wires.

C E, C E. Tube leading to engine-warner; *vide* Figs. 4 and 5 with explanation.

Fig. 4. Application of the electric telegraph to level crossings, approaches to stations, and switches, &c.

1 A, 2 A, 3 A. Telegraphs fixed in policemen's boxes, one or two miles from a level crossing or station.

C. Protecting tube for the conducting of telegraph wires, either carried on posts with a railing over it or under ground.

D. Telegraphs at stations or level crossings, corresponding with 1A, 2A, 3A.

1 E, 2 E, 3 E. "Engine-warners," (for details *vide* Figs. 5, 6, 7 and 8,) by which an engine gives notice of its approach, at the distance of one or two miles, both to A and D, Fig. 5. If the station or crossing be clear, D replies to the policeman at A to allow the train to "Go on," or else to "Stop," according to circumstances; the engine-man never venturing to pass A till the policeman has given the signal to "Go on." This will ensure the watchfulness of the policeman; but even in case of his absence, the conductor would inquire by the telegraph A for permission from D to proceed. In the figure, the policemen at 1 A, 2 A, Fig. 4, have received permission from D (as is indicated by the pointing of the handles of the telegraphs at D, corresponding with the indications on the telegraph both at D and 1 A, 2 A,) to allow their respective trains to proceed. The policeman notifies in the usual manner, by the white flag, or signal that the line is clear. The train 3 c had been stopped by the policeman at 3 A, in obedience to a signal from the station D, in reply to the "warning" given by the engine of its approach from 3 E.

N.B.—The signal given from the "engine-warner" E, at A and D, is "Stop," accompanied by the ringing of an alarum. This signal remains till answered from D.

Fig. 5.—Telegraphs for giving two signals, as represented above at A, B, and D, each having an alarum (a), which sounds when a signal is given either from E, D, A, or B.

Thirty-one telegraphs, giving two such signals, are working from eight in the morning till ten at night, on the Blackwall Railway, between the stations and the termini, to direct the working of the fixed engines.

E represents the details of the "engine-warner."

An upright bolt passes through one rail of the "approaching" line of road, the upper end rising slightly above the rail, so as to be depressed by an engine-wheel, or other very heavy body passing over it. The lower end of the

Terminal Telegraph.

Fig. 6

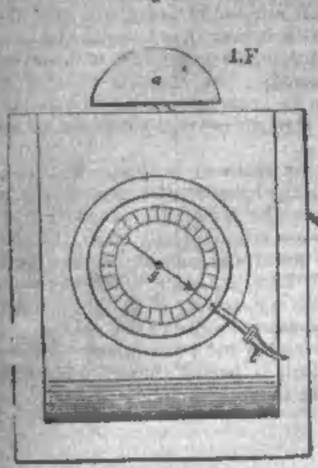


Fig. 7.

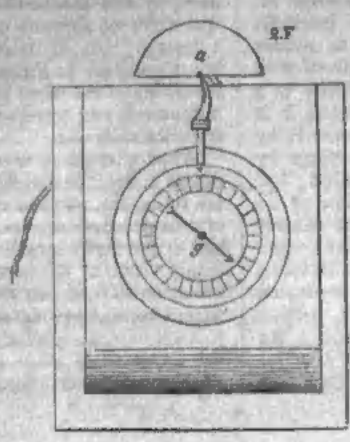
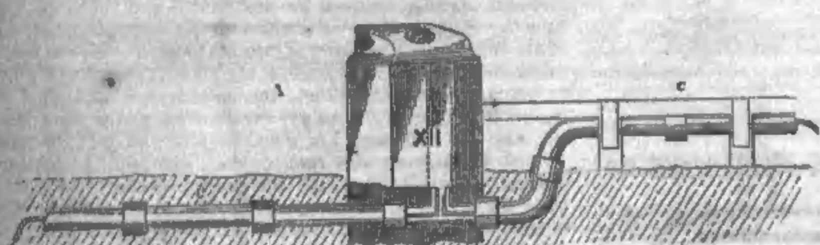
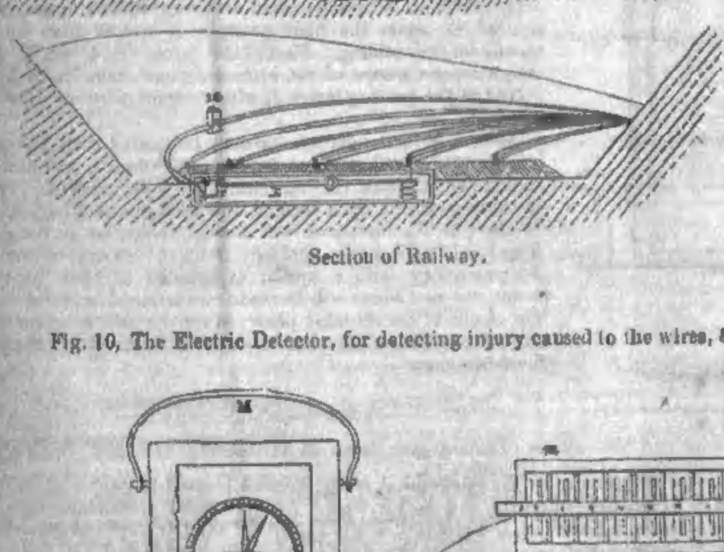


Fig. 8, An Intermediate and Portable Telegraph.





Section of Railway.

Fig. 10, The Electric Detector, for detecting injury caused to the wires, &c.

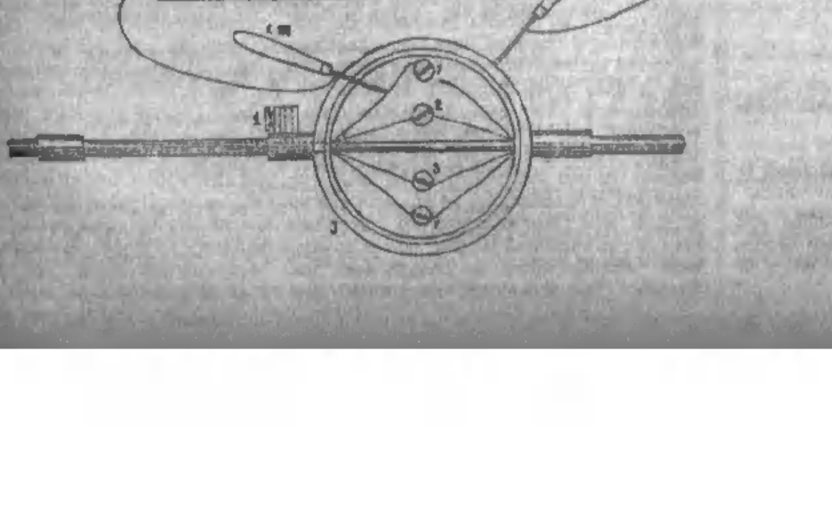
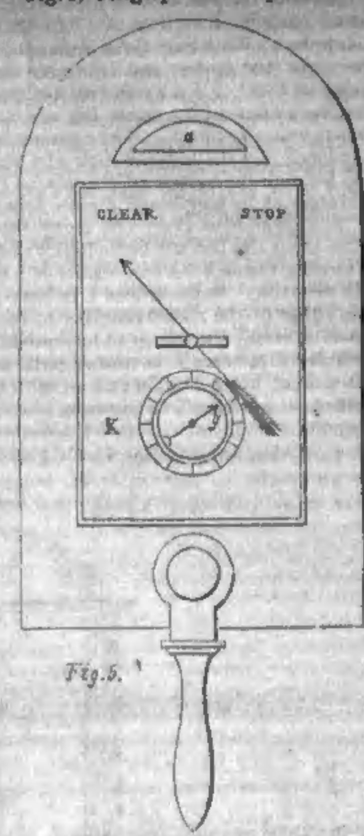


Fig. 9, Telegraph of a simple form.



bolt rests upon the arm of a lever supported by a spring capable of offering a resistance equal to at least half the pressure of one wheel of a carriage.

Upon a train passing, one arm of the lever is depressed, which, raising the other arm, breaks the electric circuit at e, and causes the alarum to be sounded and the warning signal to be given at A and D; the other wheels of the train produce no further effect till the warning has been replied to from D, which at the same time restores the electric circuit of the "warner" for another signal. Though the "warner" might be let off by mischievous persons with a crowbar, no inconvenience would be occasioned beyond arousing the expectation of the policeman for the time occupied by a train in passing the space between E and A, when the fact would be discovered, and reported by a signal to D. The object of the "warner" may obviously be attained by a variety of simple mechanical means.

Figs. 6 and 7.—Terminal telegraphs, for more extensive communications than those already described, giving 30 or 60 signals by the pointing of a revolving index-hand at letters on a fixed dial, as in a common clock; the person giving the signal turns the concentric hand *i*, till its pointer stands opposite the signal to be given, as shown in Fig. 6, when instantaneously, the index hand *g* in all the corresponding telegraphs in the circuit, viz. Figs. 6, 7, 8, &c. point at the same signal. Fig. 8 is an intermediate and portable telegraph, to be carried with each train, and applied, in case of need, to convenient arrangements at each mile-post or bridge along the line. The section of a railway below Fig. 8 illustrates this subject. An iron cap to the mile-post being unlocked and taken off, the portable telegraph is placed within a ledge fitted to receive it, making thereby the necessary connexions with the conducting wires, when it is at once fit for working with the "terminal telegraphs." This form of telegraph can be worked by any person at first sight, and requires no battery to be carried with it. It is fitted up with a water-proof cover and lantern, for rainy weather and night use.

N.B.—All forms of this electric telegraph are "reciprocal" in their action *i.e.* they give the same signals, in the working as in the recipient apparatus, and work equally from either end or from intermediate points.

Fig. 9 represents a very simple form of telegraph, on exactly the same principles as Figs. 5, 6, and 7, but combining the powers of both; the arrow giving two signals, for the purposes explained when applied to tunnels, level crossings, &c., and the small index K being adapted for a more extensive communication, when circumstances require it.

Fig. 10, M is the Electric Detector, for detecting injury caused to the wires, either by contact with the pipe or with each other, fracture, or water.

m, is a small battery; 1 *m*, 2 *m*, are "feelers," in connection with the battery and detector. Whenever these feelers touch each other, an electric current passes from the battery and influences the index of the detector M, by turning it on its axis. J J are iron boxes which occur at short intervals along the line, each fitted with a screw lid, and so connected as to render them continuous with the tube C. The terminations of each length of wire rope one introduced into the box and each wire screwed with its fellow to a piece of wood fitted to the bottom of the box, so that the wire marked 1 is continuous throughout its length and always connected by the screw 1, by which it can be recognized at every box along the line. The openings by which the wires enter the box are hermetically sealed with composition; but a small tube passing through the box admits of a free communication of air from a distant reservoir. Suppose wire 1 to have become in partial contact with the tube, either by the metals touching or the presence of water: upon opening the box at which the wire is to be proved, the screw 1 must be taken out, and the feeler 1 m brought in contact with one end of the separated wires, the other feeler being kept in contact with the pipe. If this portion of the conducting wire is sound, the detector needle remains stationary; but upon removing the feeler, 1 m, to the other liberated end of wire, the detector index moves on its axis, and indicates on the graduated scale the degree of contact existing between that portion of the wire and the tube. Supposing the experiment to be tried again at the next box, and the contact proved to lie between the two boxes, the intervening faulty portion of wire is exchanged for the sound wire marked 0, (which is a spare wire introduced by such repairs) by this means the wire 1 is again restored to soundness; it is obvious that different portions of the spare wire, 0, may thus be employed to repair a damaged wire, at numerous short intervals along the line, without rendering it necessary to disturb the line generally; the minutest changes in the insulation of the wires from dampness, &c., can be detected by this valuable instrument, and corrected by blowing through the pipe a draught of dry air from the reservoir.

When a length of wire-rope has to be removed, in consequence of accidental injury, the connecting screws in the boxes at each end of the length are taken out, and one end of the wires to be removed is bound to the end of a fresh length of wire-rope conveniently wound upon a drum. The further end of the faulty length is then drawn out of the tube and wound upon an empty drum, as the new rope gradually takes its place. The screws again unite the ends of the wires, and the line is restored. The faulty length of wire, after undergoing examination and repair, is again fitted for use.

Each wire is separately covered with cotton and India-rubber solution, and the set of wires made into a rope, which is passed through a hot resinous varnish before being introduced into the tubes.

Fig. 11.

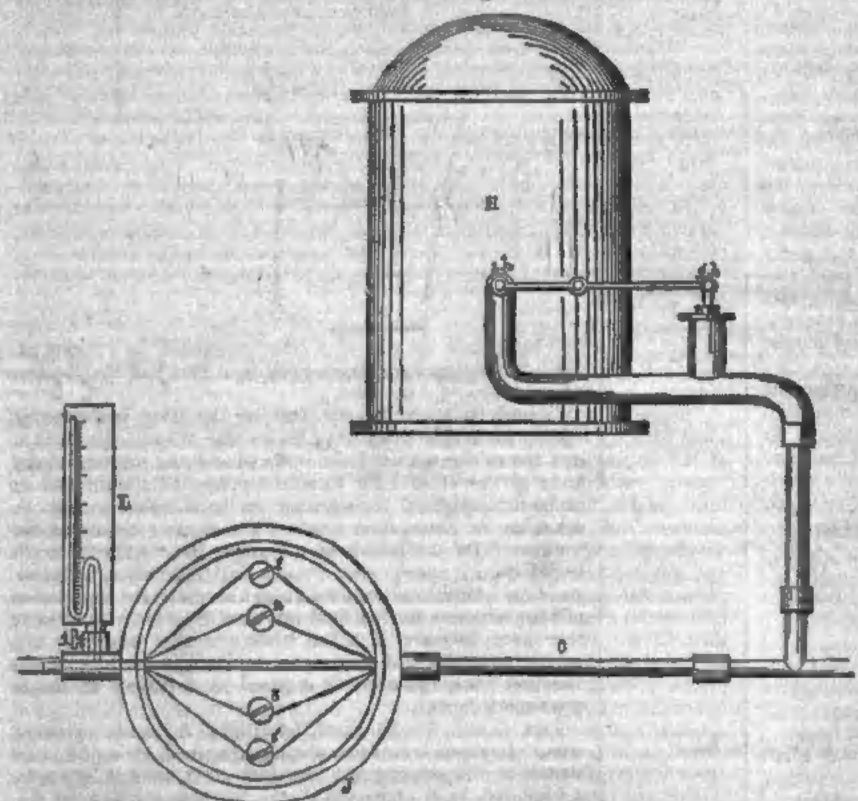


Fig. 11. Air-pressure apparatus, employed for excluding water from the tube, when carried underground; and for giving notice of defects in the tubing.

H is an air-pressure apparatus, or air réservoir, of convenient size, charged with dry air to any pressure. 1 *h* is a pressure balance, in the form of a lever; 2 *h* a valve communicating, by a minute opening, between the reservoir H and the protecting tube C. Suppose it to be found desirable to keep the interior of the tube under a pressure of two or three pounds (that being calculated as sufficient to exclude the greatest pressure of water to which the tube is liable), the balance 1 *h* must then be loaded to that amount; on any escape of air taking place from the tube, the lever arm, 1 *h*, would descend and open the valve 1 *h*, till the high-pressure reservoir had increased the pressure of the tube, which by raising the pressure-balance 1 *h*, would close the valve 2 *h*. A barometer, L, may indicate the change of pressure either in the reservoir or tube. The reservoir is supplied by an air-pump, when nearly exhausted by any leakage, which, under the light pressure of two or three pounds, should be very trifling. Should the barometer, however, indicate a sudden escape of air, attention must immediately be directed to the proving-boxes J, which occur at short intervals along the line.

In or near the box, conveniently connected with the tube, is a three-way stop-cock, to the pipe of which a portable barometer or detector, L, can immediately be applied. When the tube is faulty, upon turning the cock in one direction, the pressure on the barometer will remain steady, but in the other direction it will rapidly diminish, from the escape of the air. By proceeding with a similar experiment at other proving-boxes, the two boxes will be readily ascertained between which the escape of the air takes place; when the tube lying between the last proved points must be carefully examined to discover the faulty part.

THE ARTESIAN BORING AT PARIS.

In the Journal for April last, we gave an account of the successful operations in sinking the Artesian well at Grenelle; we are now enabled to furnish some farther detail of the geological formation through which the boring passed, from the observations of M. Mulot given in the *Revue Générale*, together with some additional information as to the size of the bore, and the geological character of the circumjacent country.

Table of the depths of the strata measured from the surface in metres and reduced to English feet.

Metres.	Feet.	
10	33	Alluvial formation, the former bed of the Seine.
41	134	Plastic clay and quartzose sand.
140	459	White chalk with black flints.
165	541	Gray chalk and flint.
506	1660	Gray chalk, very hard, with layers of micaceous clay.
546	1791	Blue clay, green clay, micaceous black clay, with fossils and iron pyrites.
547	1794	Argillaceous green sand.

Beyond here the sand continues and has not as yet been quite explored, it is in this stratum that the water is obtained.

The boring was commenced at a diameter of 0·51 metres (20 inches) and diminished by degrees as the tubes descended, the first four columns of tubing diminishing as just observed, to the depth of 145 metres (576 feet); at this point the diameter was 0·31 centim. (12 inches).

A 5th column of tubing goes down to 350 metres (1148 feet), with a diameter of 0·26 (10 inches.)

A 6th to 410 metres (1345 feet) diameter 0·21 (8¼ inches.)

A 7th to 540 metres (1771 feet) diameter, 0·17 (6⅔ inches).

The last 7 metres (23 feet) are not tubed.

The fixing of the ascensional tube is always an operation very important and delicate, and will on this occasion in particular present serious difficulties. Indeed one would suppose that it was almost impossible to lower perpendicularly a tube 547 metres (1794 feet) high into the earth, but from M. Mulot's skill, of which he has given so many proofs during the work, we are completely assured of its final success.

The quality and kind of metal which composes the ascensional tube have been studied by persons interested in the construction of the well; for many tubes of this kind have been constructed of wrought iron, and have not answered the expectations of the parties interested. A remarkable instance may be cited which happened at Saint Cyr, near Tours, at Dr. Bretonneau's artesian well. The water there rises from the sand beneath the chalk, and was tubed with iron, yet every successive year the quantity of water was sensibly diminished, and at last gave only an insignificant supply. M. Bretonneau caused the tubing to be drawn up, and although it had at least a thickness of 8 millim. ($\frac{3}{10}$ of an inch) and was well preserved, yet at the joints of each pipe there was one, and sometimes several circular holes two and even three centim. diameter, (about an inch diameter,) of which the edges were perfectly sharp, as though they had been cut out by a pair of nippers. This phenomena was probably due to an electro-chemical action,

and it shows that iron ought to be entirely rejected in the construction of ascensional tubes. Tubes of oak or elm are certainly those to which preference is always given; but the thickness which is indispensable for them, would diminish the interior diameter too much in the Grenelle well. Copper tubes of a thickness of two or three millim. (about $\frac{1}{10}$ of an inch), not only possess a sufficient resistance, but also the property of being indestructible. It is with these latter, therefore, that the Grenelle well is to be tubed.

Independently of the importance of M. Mulot's undertaking for the useful purposes to which it may be applied, it is also of great interest for the geological study of the strata through which it traverses with regard to the central heat of the globe. Taking as our starting point the constant temperature of the cellars of the Observatory, which are 28 metres (91 feet) deep, the temperature would present a uniform increase of a degree centigrade for every 32 metres (105 feet) in depth. The temperature of the water of this well has been calculated at about 27·6 Cent. (8·17 Fahr.)

The cretaceous formation, passed through by the well of Grenelle, has been deposited in successive layers in an immense basin, formed by the formations anterior to this part, of the secondary formation; the borders of the inferior strata of the chalk formation, crop out in many places, some on the edges of the basin and others a little below the soil; they not only receive the infiltrations of the rain water, but also those of rivers that flow over the exposed strata. A complete identity has been found to exist between specimens of brown free stone and green sand obtained in very different places, and very far onefrom another, and specimens from M. Mulot's boring. At Lisieux in Normandy, the inferior part of the cretaceous formation reposes on the Jura formation;—the limit of which formation extends towards Mans and La Flèche, and receives in this part considerable infiltrations from the Loire, which flows direct upon it N. E. of Angers. The Loire ought also to furnish water to the lower part of the formation near Saumur; the boundary then passes south of Paris by Loudun, Châtellerault, to the north of Bourges, and then to Sancerre. In all these different localities it receives the waters of the Vienne, Creuse, Indre, Cher and Loire; at Sancerre this limit takes a north-east direction passing near Auxerre, Joigny, and Troyes, and receiving the waters of the Yonne, Seine, Aube, and a great many other rivers of less importance. Near Troyes,* at Lusigny, and at the Abbey of Monster-Rancey, at four leagues south-east of Troyes, the brown free stone and the green sand crop out. In its northern direction through Sainte-Menehould this boundary receives the waters of the Aisne very considerably. Lastly, this formation forms the bottom of the tertiary formation of Belgium, where it receives other infiltrations that feed the Artesian wells of Picardy and Artois, &c.

All those waters filter freely enough through the sand of the cretaceous formations, and from thence pass and accumulate at the bottom of the basin, continuing to be in direct communication with the points of infiltration. As these points are so much elevated above Paris, the waters rise, and will rise still more in the Grenelle well when it is completely tubed, to a height which will be a measure of the amount of pressure exercised on the layer which forms as it were the roof of the bottom of the basin.

* The specimens from Lusigny were presented by M. Volfardric, who observes that the height of the well above the level of the sea is 130 metres, whilst that at Paris is only 61 metres.

ON THE GIVING WAY OF EMBANKMENTS.

The following remarks on the giving way of embankments, by M. Colin, principal engineer of the bridges and embankments of one of the largest canals in France, are the results of many years practical acquaintance with the subject.

The first appearance presented by a slope that has given way is that of an alteration more or less complete of its primitive form, whether natural or artificial. On examining the facts which strike the eye of the observer it, must be at once admitted that the cause of the fall of a mass of moving earth must have operated either at a certain depth, or near the surface of the slope; therefore it is requisite, in all cases, to distinguish the superficial slips of earth from those that have a deeper origin.

When a mass of homogeneous earth is composed of argillaceous matter, which is liable to give way, the strata may be more or less inclined to the horizon. When the slip occurs on a pre-existing surface, the following considerations will not be applicable; the slips of this kind are very rare, and are only accidental occurrences, which we should be careful not to confound with the general facts examined by M. Colin.

The mass of fallen earth whether natural or artificial, could not have been in a state of equilibrium in relation to the cohesion of its particles, which on the one hand tended to hold it together—and to gravity, which, on the other hand, tends to destroy the cohesive attraction. When this equilibrium is destroyed it must happen that the slope, or a part of it, will experience a spontaneous fall.

When by the action of the fall the moving mass is detached at such a depth that it preserves its central cohesion notwithstanding the fracture, which has destroyed the cohesion only on the surface of the slip, and notwithstanding that relative alteration in the angle of the strata which compose that mass,—in such case the cause of the slip must be pronounced to have proceeded from below, in contradistinction to that fall which occurs when the moving mass is detached nearer the surface, and when the cohesion of the mass is more or less destroyed by the action of external agents. It often happens, however, that both these kinds of slip occur at the same time.

This characteristic difference depends on the chemical nature of the soil, so that the same kind of slope may in one case experience a falling away from the surface alone, when in another case the cause of the slip may be more deeply seated.

There is another important difference between slips of earth proceeding from the surface and from below, which is, that the extent of the former is immediately known, while that of the latter may go on gradually increasing, according to the influence of rain, frost, and thaw. In every case, however, it is the action of gravity which causes the disturbance of the equilibrium; for the destruction of cohesion by the external agents is only an action eminently statical; the force of gravity alone causes the movement. It is therefore natural to infer, that as the principal cause of the destruction of the equilibrium is the same in all cases, the dynamical results must also be the same. Consequently the surfaces of slips, whether they proceed from below or from the superficies, ought, theoretically speaking, to be of the same kind, and to present, as regards their material points, a striking resemblance.

On examining with great care the general facts concerning these two kinds of spontaneous slips of earth, the angle of inclination of the falling earth, and that of the surface on which it falls, and comparing them with a great number of facts collected in various places, with different kinds of soil, and under different circumstances, by other engineers, as well as by M. Colin himself, he thinks he has established as a principle the following proposition:—

"When masses of earth nearly homogeneous, whether natural or artificial, are composed of such materials that the action of gravitation may, under the influence of certain physical circumstances, overcome the cohesion of their molecules, the results are spontaneous movements, which are called slips. These movements are independent of the height of the slopes on which they occur; they always present, nearly in the same degree, the character which appertains to them; lastly, and above all, the natural surface of separation, or the surface of the slip, has no pre-existence, and possesses a constant and regular form, which approaches more or less exactly, according to different circumstances, to a surface of a cycloidal shape, which brings the causes of its formation essentially within the domain of mechanical science."—*Inventors' Advocate.*

HEREFORD CATHEDRAL.

The public are already aware that very extensive improvements have for some time been going on in this beautiful edifice under the superintendence of Mr. Cottingham, the celebrated architect. We have already described the various restorations in the choir, Lady Chapel, &c., but all the interest in these (and it has been very great) is altogether lost in the discovery by the architect that the tower of the cathedral, with its immense superincumbent weight, is in imminent danger of falling, and crushing the mighty fabric in one general ruin. Before entering into a somewhat technical description (which may perhaps be understood only by a few) of the appearances that lead to this conclusion, we may observe, that we have examined the present state of the tower most minutely, and the fissures in the masonry at the angles of the Norman arches of the transepts are truly frightful. In some places the workmen may insert a piece of wood or any implement to the depth of two feet; and we particularly noticed that one of the stones forming the masonry had given way, not at the joining, but in the solid part itself, being literally split in two. It appears that some cracks in the chief wall of the tower led Mr. Cottingham to examine into the cause. He accordingly proceeded first to ascertain the state of the main piers below in the body of the church, and these he found to be all solid. He next explored the masonry of the unsightly piers under the Norman arches of the north and south transepts, and ascertained that the arch was quite independent of this enormous body of masonry; that is, that the Norman arch had "stuck firmly to its work," and that, as has long been suspected, the piers were no support whatever. Mr. Cottingham next examined the string course round the bell chamber, which supports the 52 solid stone columns above that chamber, and he found that this course (or wall, as we should call it) was rounded in the centre, and dipping down at the angles of the tower. This proved that the ancient Norman arches were still in their original position, and that the fractures which now exhibited themselves in every direction were occasioned by some defect in the main piers of the tower. On taking up the bell-ringers' floor, Mr. Cottingham found the stone groining (which was put up about the time of Edward IV.) also pressing upon the four angles of the tower. It is singular that the "pockets," or angular spaces of this groining, were filled up to the level of the floor with solid rubbish. On removing this, a most extraordinary failure in the masonry fully developed itself. At each end of the four angles was a hollow chamber running diagonally through the main wall, which, from the pressure of the enormous stone piers above alluded to, was crushing in in every direction. All the bond of the interior ashlering was ascertained to be broken, and the stones fractured into innumerable pieces; indeed, the failure is awful to contemplate, and we may congratulate the public that the discovery was made previously to any further pressure, which must have occasioned the total destruction of this magnificent tower, together with the choir, the transepts, and the eastern portion of the nave. When, or

under what circumstances, so awful a catastrophe would have occurred, of course not even those best acquainted with the subject could pretend to describe. Mr. Cottingham has caused about 150 wagon-loads of rubbish to be removed from the tower in order fully to ascertain its state, and there can be no doubt that the measures he intends to adopt will give full security. One great advantage, too, of his plans will be to expose the 52 stone columns of the tower (a remarkably fine piece of masonry) to the view of persons in the church. In the mean time, so imminent does he consider the danger, that he will not suffer the bells to be rung, and all attention to the other parts of the works is suspended until satisfactory reparation has been made. The restoration will now be effected at a comparatively trifling expense; had the discovery not thus timely taken place, the cost would have been enormous. It is worthy of remark that so little were these subjects understood only a comparatively short period ago, that the western front was declared to be secured for hundreds of years, and yet in six weeks only from the time of that declaration it was a mass of ruins.—*Hereford Journal.*

LIVERPOOL DOCKS.

It will be recollected that in the last February number of the Journal, we gave a letter of Mr. Hartley's, the Dock Surveyor, addressed to the Liverpool Dock Committee, in consequence of certain charges being brought against him by a Member of the Committee, whereupon a Sub-Committee was appointed to inquire into the charges. This Committee have lately made their report which is now before us, we are happy to announce, what we feel assured the whole of the profession were prepared for, that it completely vindicates Mr. Hartley from the charges. The report is too long for insertion in our Journal, but the following announcement we are sure will be all that is necessary for us to give.

"The sub-committee, having personally examined the accounts at the Dock-yard, and the system of checks on labour and expenditure of stores, are unanimously of opinion, after a very strict investigation of the stock accounts, and careful examination of the books, which show in detail the expenses incurred in every department of work, and making allowance for the expense of the establishment and maintenance of a large stock, that the various works have been executed on very reasonable terms, and at lower rates than they could have been in any other way. The interests of the Dock Trust, in the conduct and management of the mechanical departments of the Surveyor's establishment, have been materially promoted by the system which has been pursued; and, as long as that system is kept up in the same orderly, vigorous, and efficient manner, no better system can be devised for the general benefit of the trust, the establishment being highly creditable to the Dock Surveyor, *whose indefatigable zeal, honour, and industry cannot be too highly commended.*"

Removal of Sunderland Light House.—At a late meeting of the Commissioners of the river Wear, the taking down of the Light House being discussed, as part of the plan of building the new North pier at the mouth of the harbour, Mr. Murray, the engineer, suggested the removal of the Light House, in its present entire state, to the eastern extremity of the new Pier, a distance of about 420 feet, so as to make it serve the double purpose of a stationary and a tide-light. Mr. Murray exhibited a model of the building, and after explaining how he proposed to effect this undertaking, the Board decided that he should proceed forthwith to remove it. This Light House was erected about 40 years ago, by the late Mr. Pickernell, then engineer to the Harbour Commissioners. It is wholly composed of stone; its form is octagonal, 15 feet in breadth across its base, 62 feet in height from the surface of the pier to the top of the cornice, where it is 9 feet in breadth across, and the top of the dome is 16 feet above the cornice, making a total height of 78 feet; and its calculated weight is 280 tons. Mr. Murray intends to cut through the masonry near its foundation, and insert whole timbers, one after another, through the building, and extending 7 feet beyond it. Above and at right angles to them, another tier of timbers is to be inserted in like manner, so as to make the cradle or base a square of 29 feet; and this cradle is to be supported upon bearers, with about 250 wheels of 6 inches diameter, intended to traverse on 6 lines of railway to be laid on the new Pier for that purpose. The shaft of the Light House is to be tied together with bands, and its eight sides are to be supported with timber braces from the cradle upwards to the cornice. The cradle is to be drawn and pushed forward by powerful screws, along the railway above mentioned, on the principle of Morton's patent slip for the repairing of vessels. However surprising the removal of such a building may appear to many, yet in New York, for some years past, large houses have been removed from their original situation to a considerable distance, without sustaining any injury. The immense block of granite, serving as the pedestal of the equestrian statue of Peter the Great, at St. Petersburgh, was conveyed four miles by land, and thirteen by water. Several Obelisks have likewise been transported at different times from Egypt to Europe; and lately, one was conveyed from Thebes, and erected by the French at Paris. But the fact that the Light House on our North Pier is composed of stones of comparatively small dimension, its great height, and small base, make the operation of removing it much more difficult than any thing of the sort ever attempted. We heartily wish the enterprising engineer every success in his bold and novel undertaking, which is to be carried into execution in the course of a few weeks from this date.—*Sunderland Herald.*

COMPETITION FOR THE MARSEILLES EXCHANGE.

The following conditions of competition for designing an Exchange at Marseilles, we have translated from *Revue Générale de L'Architecture.*

1st. The situation will be chosen in a *perimètre* commencing at the "Rue de la Prison," and proceeding up to the "Place de Justice," the Grand Rue as far as the Courts.

2nd. The competition designs must contain, not only the Exchange strictly so called, but also the Chamber and Tribunal of Commerce, the syndicat of the money-changers, the royal brokers, the merchant counsel, and all the necessary appendages to these, such as peristyle porticos, vestibules, vestries secretary's office, registry office, bureaux, counting houses, &c. &c. Also a dwelling place for the porter, a guard-house for a detachment, and a place to deposit cloaks, umbrellas, and walking sticks.

3rd. The great hall of the Exchange, including the interior porticos must contain at least 3000 persons, and consequently have a superficies of not less than 1000 square metres.

4th. The drawings must be done with care, the sections to be in a pale colour, the horizontal sections in Indian ink, and carmine for the vertical sections, yellow for the wood, Prussian blue for the iron, grey for the metallic roofs, and brick red for the tile roofs.

5th. Each design must be composed of the following separate pieces.

1. An explanatory and justifiable report.
2. A general plan of the whole.
3. A plan of the ground floors at one or two metres above the level of the great hall, and the same of the first floor.
4. Longitudinal and a transverse section through the interior of the edifice.
5. Front and back elevations.
6. Profiles and details of execution (this need not be paid so much attention to).
7. A descriptive device containing a scale of the works, and the cost after the current price of the country; the whole exactly and summarily expressed.

6th. As to the order of architecture, the best in whatever order it may happen to be chosen, and even the several orders may be blended, but keeping at the same time a tone of convenience, solidity, elegance, good taste, a noble simplicity, and a wise economy.

7th. The scale of the general plan to be, 2 millimetres to a metre, that of the sections and separate plans a centimetre to a metre, and that of the details of execution 5 centimetres to a metre.

8th. The competition is fixed at six months date from the 1st April. During the following fortnight the competitors to deposit their designs at the secretary's office, at the Chamber of Commerce, where they will receive a certain number according to the order of presentation, the names and address of the competitors must be enclosed in an envelope carefully closed, to which the same number will be affixed. Each competitor to have a receipt stating the formal deposition, the number of plans, and the particular number given them, but without indicating name or person.

9th. When the term for the preparation of the plans has expired, the designs will be submitted to the judgment of a committee chosen from the members of the Chamber of Commerce, and an equal number of artists. The decision will not be definitive until the sanction of competent authorities be given, and then the names only of the authors of the three best designs will be announced.

10th. The first design will receive the prize of 3000 francs (120*l.*), and then, without further remuneration or honours, will remain the property of the Chamber, who will have the right to alter it at their will, and to confide the execution to whom they please. The names of the other two authors of the second and third best designs will be honourably mentioned.

11th. Every design (No. 1 excepted), will be restored to their authors, as well as the sealed envelopes containing their names, on the production of the previously delivered receipts.

Marseilles, March 30, 1841.

CANAL STEAMER FITTED WITH MR. P. TAYLOR'S REVOLVING SCREW PROPELLERS.

On Wednesday the 5th of May, we had the pleasure of inspecting a new steam boat on the river Irwell, fitted by Messrs. Peter Taylor and Co., of Hollinwood, near Manchester, with steam engines and propellers of an entirely new construction, both inventions of Mr. Peter Taylor, and for which he has obtained patents. The vessel is 75 feet long and 10 feet wide, and built (with the exception of the gunwale and paddle-box,) entirely of iron. She appeared to perform very satisfactorily; at a speed varying according to the depth of water from about eight to nine miles per hour, which upon a confined water we believe has never been attained by any steam vessel. In noticing a trial some months ago of another vessel belonging to Messrs. Taylor and Co., which had then been newly fitted with similar propellers, we gave a description of the apparatus, which consists of a number of continuous curved vanes or segments of screws, or wings on two axes. In the instance now under notice five pairs are affixed upon one axis, and five pairs upon the other; the number being regulated by, and varied according to, the power of

the steam engines and the extent of surface of the vanes or blades, which have the appearance of small windmill sails, and have been very appropriately named *revolving screw scullers:* each set consisting of five pairs are six feet in diameter. The vanes of one set work betwixt the vanes of the other in the same manner as the teeth of cog wheels; by this arrangement the two sets, although six feet in diameter, are together contained in a paddle-box (there being only one): it is 9 ft. 8 in. in width, and placed at the stern of the vessel; the smallness of the space occupied offering great convenience for passing locks.—The scullers are well protected from the banks or sides and bottom of the canal, with which it is almost impossible they can ever come in contact. The paddle-box occupies seven feet in length, and has the effect of extending the boat so much. The width or breadth is regulated by the width or breadth of the boat, which in the present instance is 10 feet outside. The two shafts or axes are placed at an equal distance from each other, as well as at equal distance from the sides of the boat or box containing them, and with which they run parallel; and as we have before observed, the shafts or axes are so arranged in respect to each other, that the vanes or oblique surfaces of the one can enter between the vanes of the other shaft or axis; thus obtaining a great extent of propelling surface within a very confined space. The axes are placed considerably above the water-line, and the curved oblique vanes or scullers are affixed upon the shafts or axes in opposite directions, that is, they are affixed upon one shaft or axis in such a manner that they may be said to form parts of a right-handed screw, and upon the other shaft or axis, so that they may be said to form parts of a left-handed screw. This novel propelling apparatus is worked by a pair of *semi-rotatory steam engines,* also Mr. Taylor's invention. The steam boiler is of the same description as those used upon the railways. It is placed towards the stem of the vessel, and the steam engines close up to it. To one axis of the propelling apparatus is coupled a shaft, which runs lengthwise to the steam engines. The starting, reversing, and stopping apparatus is connected with the regulator of the steam engine, and affixed at the stern of the boat, within reach of the steerer, who manages the whole when necessary. This is a most simple and beautiful arrangement, the helmsman being altogether independent of the engineer. He can start, stop, or reverse the engines at his pleasure. The helm or rudder is placed in the usual position, and is immediately behind the propellers.

The vessel has been engaged during the last month on the Bridgewater Canal towing boats; at one time she towed six boats, their united cargo being equal to nearly 600 tons, at the rate of three miles per hour, and at another time she towed four fly boats equal to 60 tons, a distance of six miles in one hour 16 minutes.—*Manchester Times.*

BENEVOLENT INSTITUTIONS OF THE ENGINEERS.

Since the notice which we gave in our last, the promoters of the plans for giving relief to the members of the profession and workmen employed by them, have succeeded in organizing an institution for each of their respective objects. That for the relief of distressed engineers has received the countenance of the Institute of Civil Engineers, and the Society for the workmen goes on, receiving increased support from the mechanical engineers, who we trust will give every support to an object so well deserving; a subscription list is now open, it has been, we are happy to say, liberally signed by the masters.

KING'S COLLEGE.

We are glad to learn that the department in King's College hitherto devoted to engineering, and to the mechanical and manufacturing arts is about to be extended, so as to embrace also the principles and practice of architecture. The existing provision in King's College for the education of the engineer having also drawn thither students in architecture in search of instruction adapted to their pursuits, the desirableness of the proposed extension became evident. King's College is then likely to be the first collegiate establishment to undertake the preliminary education of the architect as such, as well as in literature and science generally, and we cannot doubt of its success in so doing, nor of the good that will be thereby effected both to the profession and to the public.

Monument in Westphalia.—A remarkable monumental structure is at present raising, or about to be raised, in that part of Westphalia where Arminius overthrew the Roman legions, commanded by Varus, to commemorate that event. The monument is to consist of a statue of the German hero, similar to the many images which may still be seen under the name of "Ermin Saeulen," in various parts of Germany, and which became, in the early periods of the Christian era, objects of idolatrous worship. The statue is to be of copper, 42 feet high, and to the point of the uplifted sword 75 feet! It is to be placed on a circular temple 90 feet in height, on the top of the hill Teut, in the Teutoburger forest. The monument promises to do honour to German art, and the idea of erecting such a work is a proof of the patriotic feeling of the Germans. The expenses are to be defrayed by subscription, and all the sovereigns of Germany have contributed.

SEVERN NAVIGATION IMPROVEMENT.

Abstract of the Engineering evidence for improving the River Severn, given before the Committee of the House of Commons, on the Bill, May 5, 6, 7, 10 11, & 12, 1841.

Mr. E. L. Williams, Engineer, was examined and stated that the fall in the Severn is slight compared with the Thames. The fall in the Thames from Abingdon to Henley is 2 feet per mile. The fall in the Severn in this district is about 9 inches per mile. On the Thames also there were the conflicting interests of millers and others who had private rights connected with the water which was not the case with the Severn. The operations on the Thames have been to the benefit of the navigation. The course of the Severn is comparatively straight, and its width comparatively uniform, which circumstances are favourable for our operations. I attribute the shoals of deposit to variations of width. There is little tide above Gloucester, and this will not affect us. Our first weir is below Upton. We propose there to make a lateral cut, with a lock in it with a lift of five or six feet. Between Upton and Gloucester below the lock we propose to equalize the area, or water-way of the river, by contracting it by embankments in certain parts and widening it in others. The effect of contracting it will be to preserve clear what we have dredged. We shall contract the area by decreasing the width and lining the banks with stone. I have experience of the natural way in which the water-way is preserved. The finest channel in the river is from Sandy Point to the Mythe Bridge near Tewkesbury, which preserves the water-way throughout from the quality of the sectional area. I infer that if we form the same results we shall produce the same effect. The average depth there at low summer water is from 10 to 12 feet throughout. I anticipate that the artificial banks will be principally confined to the district between the Mythe and the Haw Bridges. This space includes the Deerhurst and other shoals which we propose to dredge. I have here the sections of what we propose to do. The first shoal of importance we propose to dredge is at Gloucester, in the eastern channel alongside the Quay at Gloucester, extending from the lock of the Gloucester and Berkeley Canal to the other bridge. In fact we propose to dredge to a trifling extent from the Westgate Bridge to Sandhurst, a distance of two miles. In the western channel we propose to dredge sufficiently to allow canal boats to enter the Gloucester and Hereford Canal. We then come to Wainlode Hill; there is not much dredging to be done there. We then come to the Haw, which is laid down for dredging to a certain extent, but not requiring the shoal to be taken out. There is a section laid down for the other channel, and there is sufficient water for the purposes of navigation under one arch of Haw Bridge. We then come to Deerhurst, where the area is to be equalized and the channel dredged. At Sheplock we do the same thing; also at Lower Lode up to Cumberland, where similar operations are required. We then come to Bushley Reach and Saxon's Lode, where we dredge and equalize the area. Then we come to Upton, where we make our first lateral cut. There will be no interruption to the navigation while the cut is being made, and when the weir is being made the lock will be open. The lock will be 20 feet wide, 100 feet long, with 5 ft. 6 in. lift. We then place our weir obliquely to the current, about midway between the upper and lower entrance. The length of the weir is 600 feet. It will be constructed with sheet piling and rubble stonework. The height of the weir above the surface of the present bed of the river will be seven feet. The effect of this weir will not prejudicially affect the drainage of the surrounding district. I have surveyed the falls of the lowest drains in the district, and find the lowest will be above our permanent water line. This answer will apply to all the drains throughout our operations. I have taken the greatest pains to satisfy myself on these points. We do not raise the water there in any way; and I believe the effect of the works will be to expedite the passage of flood water and not to detain it, because we clean out the channel. Above Upton we do raise the level of the water in some places, but in all cases it will be below the drains. I have made a section of Lord Sandy's drain. I find there is a fall of 9 feet in the first 100 yards of the land drain. The drain itself is below the weir, and consequently cannot be affected by it. We then come to the shoal at Ryal Watering, and take a little off the top of it by dredging. At Hanley we do not dredge, as we shall get sufficient water from the pound to pass over. Dredging with simultaneously pounding back the water would produce a bad effect. At the Rhydd we take the top of the shoal off. At Clevelode, Pixham, and Kempsey, we do the same. These are the shoals mentioned as affected by dredging. We then come to the Ketch shoal, which is to be dredged. The Silver Ford shoal is to be dredged slightly. We then come to lock No. 2, which will be similar to the previous one, a cut with a lock in it, each of the same dimensions as the other, with a lift of 7 ft. 6 in. and a weir. The water is penned back sufficiently at Upton Bridge by the shoal; the height of the weir will be 11 ft. 6 in. from the bed of the river, the length 400 feet; it will also be placed at a sharp angle, and constructed in the same manner as the other; the piles are elm, oak, and fir. After the water has passed over the dam of sheet piling, it will fall on a dam of stone work, and we thus prevent a pool there; this will remove the obstructions immediately above. We have now passed Worcester and are come to Bevere Island, where is our third lock; the river there divides itself into two branches, which supersedes the necessity of an artificial cut, and we deal with it as such, placing a lock of the same dimensions in one branch and a weir in the other; the lift is 4 ft. 6 in., the length of the weir is 400 feet; it will be placed obliquely as the others; with some trifling dredging this is sufficient up to Holt, where we have another lock, No. 4. The length of the proposed cut is about a quarter of a mile on the Ombersley side, on Lord Sandys' property. I know of no damage that the estate can suffer by our taking that bit of ground. Our works will not be in sight of Ombersley House, which is a mile and a half to the left; the length and construction will be the same, the lift 4 ft. 6 in.; the locks will be built of brickwork; the length of the weir there will be 350 feet, the height 7 feet from the bed of the river; the obliquity is to give facility to the passing of the water, this will operate to prevent dredging except very slightly up to Lincombe Hill, where is our fifth and last cut;

the lateral cut is shorter here than the others, it is about 14 or 15 chains or 350 yards, the lift is 7 ft. 6 in. the dimensions are the same as the others, the length of the weir is 350 feet, the height from the bed of the river is about 11 ft. 6 in., the width of the river is from 100 to 130 feet. This takes us up to Red Stone Rock, and Cloth House, and to Stourport; the weir is to be in the cut there and the lock in the river, because the towing path is on the eastern side of the river, and we should have to pass over if we put a lock in the cut; I can't give the height of this weir. We dredge between Gloucester and Upton, because the shoals fall so much less in this district and are of a different character; they are shoals of deposit formed by the inequality of the sectional area of the channel. The shoals above Upton are hard beds of gravel and marl, which pen the water over in the summer season. The effect of dredging from Upton to Worcester would be to increase the liability of the banks to tumble in, and would also be inconvenient to the trader from the increased height of the banks, which are already too high: the same effect would be produced in a greater degree by dredging Upton shoal, unless there was something above. Compared with the present plan, dredging would be much more expensive, supposing it formed part of a continuous plan up to Stourport. If you removed the lock from Upton and put it at Diglis, you must have a double lift there, which would be inconvenient to the trade, as in point of fact it would be two locks. The extent of dredging in such a case must be to the extent of from 7 to 10 feet, which would be a serious matter, and would make cataracts from the locks. By the system of weirs we shall have 6 feet of water at all times from Stourport to Gloucester, which I believe would be sufficient for all purposes of trade on the Severn; I do not think it would be more than necessary for the canal boats. The build of vessels would alter if the water were deeper. In my opinion the trade of the river will be increased if these improvements are carried into effect. In my opinion if the maximum toll is imposed, these advantages will counterbalance it to the trade; I found that opinion upon the excessive delays, cost of lightering, pilferage, wear and tear, the increased power required to draw vessels up, the limited number of voyages and the light cargoes, which exist at present. The trade of Gloucester has suffered much in consequence, and has gone to other ports; to my knowledge many cargoes which, but for this, would have gone to Gloucester, have gone to Liverpool; this has been especially the case lately. I believe also that railways have increased the prejudice to the Severn. The cost of these improvements I estimate at £150,000, which will be sufficient, and more than suffice, and include contingencies, which I have estimated at 10 per cent. I am prepared to state in detail how it will be expended.

Cross-examined by Mr. Austin.

The original plan was made by Mr. Rhodes. I have been acting under Mr. Cubitt since Nov. 1825. I consider the merit or demerit of the present plan belongs to him. Mr. Cubitt was employed as consulting engineer, and Mr. Rhodes as acting engineer. I was employed by the committee of the late Severn Navigation Company. This is not the same plan as theirs, but the same with some alterations. Their plan was first made in 1836. There was a plan and sections. The original plan is at the Guildhall at Worcester. I have a reduced copy of it as altered. I took part in the formation of the original plan. It was adopted and altered by Mr. Cubitt. I said the deposit of shoals would depend on the drifts of the river. The river is divided in the plan into districts. The area of the first is at Upton, 3480 feet. That supposes a line drawn at the top of the bank and the bed of the river. The width is 104 feet, the average depth 11 feet. The next district is half a mile lower down, and has the same area; width 101 feet, average depth 10 ft. 6 in. The third is, area 3120 ft. width 98 ft. depth 11 ft. The fourth is, area 3401 ft. width 104 ft. depth 10 ft. 9 in. The fifth is, area 3529 ft. width 107 ft. depth 12 ft. The first section is half a mile below the Barley House, the second a mile ditto, the third a mile and half ditto, the fourth two miles ditto, and the fifth two miles and half ditto. That gives an average of 100 feet width and 10 feet depth, which is plenty of water for the necessities of the trade. There are no shoals there. When the water rises it expands also. The fall from Upton to Gloucester is about 7 inches, or 2·8 inches per mile. We propose to alter the whole river from Upton to Gloucester, to assimilate it at this part, and to maintain an uniform depth of 6 feet. The width of the river varies from 150 feet to 170 feet, I am not now prepared to give the Committee the detail of the cost of the works. Mr. Provis made the original calculation of the expense. The average dredging of the whole line will be less than 5 feet. The general estimate of the present plan was made by Mr. Cubitt at Worcester, in the autumn of last year. We had not a detailed estimate until within the last two months. I do not know that it is determined to lay down a quantity of rubble stone to be used between Upton and Gloucester. The depth of the water at the Upton weir immediately above is 7 feet, and below, 3 ft. 7 in. We propose to use the stuff dredged up in equalizing the width. Mr. Provis took the price of the stone from me. It was from 3*s.* to 3*s.* 6*d.* per yard, delivered not at the spot, but on the Severn. Part of it comes from between Worcester and Stourport, and the other part from Malvern. I can't tell the cost of the stone and timber between Worcester and Upton. We propose to coffer-dam at Bevere Island. The soundings for the shoals were under my direction. The borings were in many instances from 8 feet to 10 feet. Maisemore shoal was not bored, it being out of the direct line. We bored all the other shoals. We took 26 borings in the Worcester shoal.

By Mr. Serjeant Wrangham.—I do not know the quantity of work to be done for the purpose of improving the navigation. It will be a work of considerable amount to get a depth of five feet at Deerhurst shoal with a width of from forty to sixty feet. The dredge below Upton Lock will be on an average of from 4 to 5 feet for the same width for the length of a mile. I believe these excavations will not depress the level of water because they are shoals of deposit and not natural formations, and there is no fall from them. By dredging to Worcester you would be making the river a succession of rapids; if we deepened to a sufficient extent in low summer water we should get rid of the rapids, but we should lower the ponds above; it would do so even with the same sectional area. By narrowing the banks and increasing the depth the stream would flow faster; the shoals do not pen the water back except where it acts as a natural dam. From Diglis lock to Upton weir the total depth is 4 ft. 6 in.; this space contains a great number of rapids; the fall is 4½ inches per mile, with a soft bottom, but with a shoal of hard gravel and marl. I think that dredging up to Upton would not retain the level; there would be a diminution at Diglis lock of 3 ft. 9 in. by dredging, if the water was not penned back by our lock; that would leave a fall of 9 inches from Diglis lock to Upton. The river is not so broad from Diglis to Upton as below Upton; and being so, the fall above is greater than the fall below, but it must not be naturally so; it depends upon the inclination of the bed of the river, and the quantity of water carried. Many rivers, particularly the Thames and the Kennett, have had their navigation improved by artificial means. The current of the Thames is much faster than in the Severn. The velocity of the flood of the Severn is from 2½ to 3 miles per hour. Mr. Provis can give you a more satisfactory answer than I, as to the force with which that would strike our weirs. I have seen a portion of the surface of the weirs in the Thames washed off by the water. They are made in a very simple way—by piles, filled up. Our weirs will be much stronger than the Thames. During the six years I have been engaged on the Severn my attention has been particularly directed to these subjects, and the information I have given to the committee is the result of that investigation. Mr. Provis was called in about two months since. I have made a calculation of the time at which the river may become free again; and taking all things into consideration, I think it may become a free river again in forty years, with the exception simply of a toll for keeping the works in repair. My estimate applies itself to the cost of tonnage. I am sure I furnished Mr. Cubitt and Mr. Provis with sufficient information to give an opinion on the subject. The time now lost in consequence of the shoals is much greater than will be lost in going through the locks. The impediments to the navigation of the river now are much greater than can possibly exist under the improvements. I have passed vessels through the locks on the Thames in 3½ minutes; about 5 minutes is a fair average. Supposing a boat to start to Gloucester in a fresh, which, before the alteration, could get back in the same fresh, it would have greater facility for doing so in consequence of the improvement of the river, notwithstanding the locks.

Mr. Provis, Engineer, examined by Mr. Serjeant Merewether:—I have executed works for Mr. Cubitt, and other engineers. The Menai Bridge was one of those works. The Birmingham Junction Canal was another, and I am now employed on works to the amount of £60,000 or £70,000. I was called in to give an estimate for the proposed works on the Severn, and Mr. Williams and I went down the river from Gloucester to Stourport, and I made my own observations in addition to the information given me by Mr. Williams. I have an estimate of the whole cost of the works, including 10 per cent. upon the cost of the works for contingencies, but exclusive of the land to be taken, which I do not pretend to value. The amount of that estimate is £133,108 12*s.* 3*d.*, being £121,007 16*s.* 7*d.* for the total cost of the works, and £12,100 15*s.* 7*d.* for contingencies. I have made such a calculation that, if the work were offered to me, I should have no objection to undertake it at that contract, providing the supervision was such as I liked. Were I employed as an engineer to examine that estimate, I should say that it is a fair sum to give to any man to do the required work. The cutting required at Upton will cost £4656 17*s.* 8*d.*; the lock at Upton (including the building, the gates, and every thing necessary to complete it,) £6321 4*s.* 2*d.*; the weir at Upton, (including all that is necessary, rubble stone, &c.) £3887. [It was here understood that the odd shillings and pence should be left out to simplify the statement.] This would make the total expense at Upton £14,865. Worcester: cutting £4210, lock £6231, weir £2848; total £13,379. Bevere: cutting £1082, lock and coffer-dam (which I think will be required there) £10,769, weir £1500; total £13,421. Holt Fleet: cutting £3347, lock £5863, weir £1658; total £10,869. Lincombe Hill: cutting £5126, locks and dams (not coffer-dams but embankments) £8072, weir £2016; total £15,214. Total of the five totals £67,750. The five lock-houses will cost £1250. This includes all the work except the equalisation and works below Upton. The total dredging will cost £18,141. Protecting the sides of the river, £33,866. These two items make £52,007. The three totals make £121,000. With the best judgment I can form, I think this is sufficient for the work. I have made estimates to the amount of millions.

Cross-examined by Mr. Austin.—The quantity to be dredged between Upton and Gloucester, including both branches of the river, is 311,000 yards, which I estimate at 1*s.* per yard. I believe that to be the full price, and I include the taking away and depositing the soil, the whole of which is proposed to be used in narrowing the river. There is no intention to take any away, except, perhaps, throwing a little into some of the deep holes, and putting some of the best gravel on the towing paths, which are very bad. This work, will come to £15,500, which is a very large proportion of the total cost of dredging, leaving only £3000 more to be expended on dredging between Upton and Stourport. It is proposed to face the channel with rubble stone, at an inclination of 3 to 1, extending from the bottom of the dredged channel to the height marked in the section to represent the spring-tide level. There will be 193,520 square yards of rubble stone facing between Upton and Gloucester, or about 132,000 cubic yards, at 3*s.* 6*d.* per square yard, or 5*s.* 3*d.* per cubic yard. The stone can be procured at the Red Stone Rock, at Lincombe Hill, and at Holt Fleet. The mode in which the facing is to be done, is first to set the dredging machine at work, and then to throw the stone promiscuously into the channel, marks being set up for the guidance of the men who discharge the cargoes of stone. The rubble stone facing was my suggestion, and Mr. Cubitt has adopted it. I cannot tell how much sand or how much gravel will have to be dredged above Upton, as the quantity of dredging is so very small that I did not consider it worth while to examine very minutely. It would be a little harder to dredge stones than gravel, but not much, because if the stones were large we should remove the buckets from the machine and replace them with claws, which would take up detached stones. I estimate the excavation at 10*d.* per yard, which includes the removal of the soil, placing it behind the stone walls, and sloping it from the top. We shall be

driven to the plan of dropping in the stones for the weir till they rise to the surface, when they will be placed by hand, except where we make a cut, and then all the stones will be laid by hand. At the foot of the weirs it is proposed to have rubble stone, sloping at an angle of 3 to 1. We propose to make our weirs water-tight by having the sheet-piling jointed and grooved, and, as it will be driven comparatively dry, the swelling of the wood when it comes in contact with the water will be quite enough to make every joint water-tight. We do not resort to puddling. I have not made any estimate of the cost of the land which will be taken, nor for any compensation in case the drainage is affected. I have only estimated the cost of facing one side of the river at any place. This estimate has been in progress two months. I have not made any alteration in it from the first, saving to correct some little mistake respecting the quantities.

Re-examined by Serjeant Merewether.—The reason why I use stone instead of dwarf piling is because it is more durable than timber, and more proper to be used; but if it became a question, and it was deemed desirable to use timber in any particular part, then I should adopt timber. There are localities near the river where we can get stone very easily. The price I have stated is quite sufficient to cover any difference in the nature of the soil to be dredged. In constructing a weir we first put in piling. I have no reason to apprehend that the stone will be carried away, because there will be a great mass of it, placed at a considerable slope; I think the weirs will be quite strong enough to resist all pressure. I have not made any of these weirs myself, but I have taken drawings of some which have well answered the purpose for which they were designed. The walls are of the same description as those adopted by me in the river Dee, which is a rapid river. My cross-examination does not shake my conviction in the least, as to the strength of the wall.

Mr. Cubitt examined by Mr. Serjeant Merewether. The following are the principal items of his evidence:—Our plan will not affect the drainage below Upton at all, and will be the best with reference to expense. The dredging at Maisemore will be so small that the effect of it upon the Gloucester channel will be inappreciable. We shall dredge in the deep water channel. The plan proposed above Worcester has been adopted because in that district our object can be better and cheaper attained by it and with less injury to the surrounding lands. As an explanation of this, six inches of water going over a weir 600 feet long would take all the summer water in the Severn; 25 inches over a weir so constructed would make a good navigation and effect a good drainage of the land, and before injury could ensue the weir would become obsolete. We seek a channel of 45 feet from Upton to Diglis, with a rise at three inches per mile. The amount of dredging here would be upwards of 300,000 cubic yards, at 1s. per yard, which would be £15,000, which is the price of all the works at Upton. The lift between Worcester and Upton Bridge must be the sum of two lifts. If the two falls be brought to Worcester there must be two locks at the double fall, which would be more expense, in addition to the cost of £15,000 for dredging. I therefore think this is a sufficient reason why the weirs and locks should begin at Worcester. I apprehend there will be no difficulty whatever in the works answering their purpose when made. In putting the weirs across the river quite square it becomes a dead stop in proportion to the height and width of the weir to a portion of the section of the river, and backs up the water; but the quantity of water that falls over the weir is never of a longer sheet than the breadth of the weir, so that were the banks full there must be an obstruction. An oblique weir is the simplest, cheapest, and most efficient to dam up the river without injury. [To elucidate this, Mr. Cubitt produced a model of the proposed works and explained them in detail to the Committee, and also the scientific principles on which they were adopted.] I have considered the point of the sluices in the weir. I think them inexpedient. The flood gates would have no perceptible effect in such a case; and flood gates, as such, in the weirs would cost more than the weirs themselves. The weir is quite as capable of penning off the water without flood gates as with them.—If any works are put to improve Lord Sandys' drain it would not impede the navigation. My object has been to raise all the works, towing paths, &c., above the floods.—I do not intend to dredge away the quantity Mr. Provis stated at Maisemore shoal, or to do more to it than will be necessary to let the Maisemore boat pass. There is more in the Parliamentary sections than is necessary to be done, and so far there is a greater degree of safety.—I was first employed to make observations on this river by Mr. Lea, the Chairman of the Association at Worcester. I made my report to Lord Hatherton, the Chairman of the Committee of the Severn Association. I had met Mr. Williams professionally before. I was engaged with Mr. Rhodes in the plan of 1836; that was a plan involving the erection of weirs above and below Gloucester; the weir below Gloucester would have been in a portion of the river now avoided by the Gloucester and Berkeley Canal. The plans of the present day are the same amended; I approved of them in general, but not in all things. I have no doubt that we might get six feet of water by dredging up to Worcester, but it would be much more expensive. It is proposed to place a wall where we dredge. I have estimated for eight miles of walling and dredging; that will answer the double purpose of narrowing the river and securing the banks.

Mr. Cubitt cross-examined by Mr. Wortley.—Mr. Williams correctly described the mode of laying down the rubble stone. At one time I proposed to use dwarf piling in some places; and I still intend to do so, where I think it will be as cheap and efficient. In some respects it is preferable to stone, in others it is not so. I can't mention any part of the river in which I think it will be preferable. I do not propose to make the slopes of the banks perfect in all places, as Mr. Provis did, because I think there will not be stuff enough to do it. The channel of the Deerhurst shoal is rather straight; the deepest water is towards the left bank going down. It is not absolutely necessary to stone up to the high-water mark. The length of the dredging on the river between Upton and Gloucester upon my scheme, as marked on the sections, is between eight and nine miles. I should remark, that it is marked deeper than will be necessary for the navigation. I do not contemplate any works below the Gloucester and Berkeley Canal, nor below the entrance to the Gloucester and Hereford Canal. The continuous length of dredging in the sections, from Upton to Diglis is nine miles. We propose to start from Upton at a depth of 7 ft. 6 in.; and we do so because I don't think 6 feet sufficient. By the 6 feet spoken of as the depth we seek, I mean 6 feet above the lock sills. I save all the dredging there by penning the banks. Were we to dredge from Gloucester to Worcester to a width of 45 feet at the bottom, to the level of the lock sill of the Gloucester and Berkeley Canal, 5 feet in depth, with a slope of two to one, and rising 3 inches per mile, the quantity to be dredged would be 323,133 cubic yards. [Witness then answered a series of questions as to the volume of water that would flow in channels of different widths.] We shall scarcely affect the fall below Upton. We propose at Upton to form a close jointed waterproof weir, slanting, 600 feet long, with timber pilings drawn into the river, 10 feet apart; behind this we propose to drop stones into the river, without masonry. The expense of having the lock at Diglis, instead of Upton, would be very much increased on account of the additional fall. In some places where we construct our weirs we widen the river, in which cases the cross sections would be as great or greater than at present. I measured that section across the river at right angles to the stream. The height of the water above the weir is 6 inches. I know by principle, and partly by practice, that when the water is 2 feet above the weir the boats will go over. The water, in coming to the weir, does not diminish its velocity, and no more water would pass over the weir in consequence of its being oblique than if it were right angled. I do not make a pond, and therefore I do not cause a deposit. If you do any thing to diminish the velocity of the water coming through the weir it will tend to form a deposit; but if it be so constructed that the water coming through can keep moving on with the same velocity, it will have no more tendency to form a deposit than before the weir was put in. If I were to carry out the works at once I do not intend to make any alteration in the length of the weir; and if I did so at all, it would be to meet the views of others rather than my own convictions. If the river be increased beyond its natural width it will be more liable to deposits. The expenses of general maintenance of the works can never cease while the works exist. The expense of the navigation of the Ayr and Caldwell is very considerable. We do not alter the natural surface of the water at Diglis locks to any extent; if the weir were placed above the entrance to the canal, vessels would have the same depth of water. The reason I have for not placing it higher up the stream is that it would lengthen the cut very much, take more land, and much reduce the water to what I may call the harbour of Worcester. The length to the harbour is 1000 yards; it would increase the length of the cut about nine chains. There would be great passing of vessels from all places at the point, and therefore I think there should be a good harbour. If the vessels coming at the same time had to wait for the lockage, it would be the best place to wait in, but there would be little or no waiting, as they would pass the lock in three or four minutes. At Bevere Island I propose to put the weir below the mouth of the Salwarp; Mr. Rhodes in his last plan has placed it in the same place. By putting a weir in a shallow stream we raise the water; but the instant it gets so much above the weir as to lose a fall, from that instant the weir is no obstruction. I have had but little experience in salmon rivers; I understand there are good salmon in the Severn, and I should be very sorry to do anything to destroy them; I have nothing to do with how far these works will affect the rights of piscary; I have considered how to form the weirs so as not to obstruct the salmon in passing up the river; the weirs will not afford any facility for taking the fish. The average yield of the river at low summer water is from 40 to 60,000 cubic feet per minute above the Avon; the quantity of course differs below the Avon.

By Mr. Lowndes.—I have not personally taken the levels of the drains on the river Severn; I received information from Mr. Williams, and a great deal from Mr. Rhodes; I don't know that Mr. Rhodes personally took the levels. I received the greatest information on this point from the documents. I examined the drain on Lord Sandys' property myself; if you proved there was an under-drain there it would not matter an atom. I consider the sole operation of a drain to be to take the water off the surface of the land; the effect of an under-drain is to take off that which gets below the surface of the land. If there is an under-ground drain it does not follow that the level must be the same as that of the open drain. I do not know whether there is an under-ground drain at this place, but I believe all the drains on Lord Sandys' property come into the Severn below the weir.—When a fresh comes down the river the surface of the river will remain nearly the same as before the weir was put in. The works will raise the water on the river at Salwarp perhaps four feet. The value of the land to be taken will be proved hereafter by other witnesses. If it should be proved that 2000 acres for instance would be injured in their drainage by the bill, there has been no estimate made of the amount of compensation for that. I can't give any opinion as to the permanency of any damage that might ensue. I admit that the consequences of imperfect drainage would be to effect the atmosphere of the district. The state of the towing paths is not good; they give way on both sides of the river. When they have given way, it is generally the case that the land is encroached upon for a fresh one, which they are entitled to do. If they are entitled by their Act to take 10 feet on the side of the river, and that falls in, I am of opinion they can take 10 feet more; notwithstanding this, I do not think it is imprudent in us to undertake their management.

Mr. Mc'Neil examined by Mr. Serjeant Merewether.—I am a civil engineer, and have been engaged in many extensive works for a period of 20 years. I have been present during the last few days of this enquiry. I have been engaged in works of a similar description to the present. Having heard the plan, I think it would effect the desired object. I think it would be best to dredge up to Upton. I think, also, that the weirs will effect Mr. Cubitt's object. With reference to expense, I think it is the best mode that could be adopted. I think the explanation given by Mr. Cubitt has been so clear, that nothing remains to be added to it.

Cross-examined by Mr. Austin.—I was called in on this business on Monday week. I had not made a previous examination of the river Severn. I never did so. I have been across it at Chepstow, but never practically examined it. I do not know any other river of a similar natural character. I

am prepared to support Mr. Cubitt's opinion of the effect of the weirs. I do not give any opinion of the proper mode of dealing with the peculiarities of the river Severn. I form my opinion on general scientific principles—that the effects described, by Mr. Cubitt will take place. I am now constructing sea walls where there will be a weir, but I have never constructed one across a river. The present weirs are of great length. I have heard of the mode in which it is proposed to construct them. I see no use for a foot frame in the present case. I think it will stand, as the stones are to be dropped in. I do not think the water will have any effect upon the stone so deposited. The pressure is removed to a great extent by the sheet piling. The water will go over the top of the sheet piling, and find its way through the stone works. It will perforate in a gentle manner, and not disturb the stone work. In flood there will be no fall at all, because it will be the same height above as below. I don't think I ever saw a large weir of this kind; I have seen small ones in canals, and I can apply the effect produced in other places to the present case. Many weirs in this country and others are formed simply by loose rubble stone. The finest I ever saw, which is on the Boyne, is so constructed. A weir of this description is made water-tight by the sheet piling above it. If it should slip I should pack it again with fresh stone; it would be little expense. I am getting packing done now at 6*d.* per yard for labour. The former stone would be available. I am aware of the object of putting the weirs across the river; it is for the purpose of getting a higher level above. It is placed obliquely, to afford greater facility for the passage of flood water. I am of opinion that it would. I have myself proposed it. It is now being done in the river Shannon. I am not engaged there, but I have made many experiments on the subject. When the weir is placed right across the river it diminishes the water way by the whole superficial area of the weir. It is the same when it is placed obliquely, until the water flows over. As soon as the water rises over the weir the circumstances are altered, and there would be less obstruction, in proportion to the length of the weir, when it is placed at right angles. The summer water would be at the same level, above and below, in either case. In time of floods the water comes down at all points of the weir at equal depth. It would always do so with an oblique, but not with a right angled one. I don't see any reason why, in an oblique weir, the water should make to the lower angle; it would pass down parallel with the axis of the river, or to the banks, if the banks are parallel. That is my deliberate opinion. This principle may be applied in all cases of flood. The water will not fall in the same manner, but will take the shortest line. If the water is rapid it will form an acute angle at the crown of the weir. I don't think water a foot deep will fall in this way. If you want to double the capacity of the weir you should more than double its length. If you did so with a weir directly across, you must widen the river.

Mr. Cubitt explained, that wherever he proposed to put a weir, if the river was not wider at that part than above and below, he proposed to widen the river at that part for the whole extent of the weir, to an extent at least equal to the cross section of the weir; the consequence of which would be, if they took the cross sections, the channel would amount to the sectional area, at least, to the section of the river above and below.

Mr. Mc'Neil's examination, resumed.—I have made experiments as to carrying a double quantity of water over a weir. I simply speak of the quantity passing over, not of its approach. Not knowing the river, I can say nothing about the dredging.

By Serjeant Wrangham.—I do not know how much it is intended by the Upton weir to pen up the water at the tail of the weir above. Whatever height of water is penned back above the present summer level at half a mile above Upton weir, will be so much abstracted from the water-way of the river. When the current passes over the weir, it will pass at a higher level than before the weir was there, by very nearly the depth of the water penned back by it, added to the depth of the column of water passing over the weir. In cases of flood the section of water-way for carrying off the flood will not be diminished to the extent of the water penned back, because the dam below is at the same time increasing in height, until it comes to the same level, when the weir becomes no weir at all. Supposing the water to be penned back within a few feet of the top of the bank, the river above being contracted, all the water that can pass will pass over the weir.

Re-examined by Mr. Serjeant Merewether.—The question just put to me relates solely to the capacity to retain, and not to obstructions and the facilities of avoiding them. The discharge of water over the weir will be in proportion to the length of the weir. I have heard of this principle for seven or eight years. The construction of the Breakwater in the Plymouth Sounds is the same as it is proposed to construct these weirs. I consider it to be the best mode of constructing weirs.—I have been professionally employed on many rivers. The weir on the Boyne stands very well. If the force of a river be five miles per hour, it would strike a weir directly across at the same force, but if the weir is oblique, the force which strikes against it is represented by a line drawn at right angles, and if the hypothenuse is five, the force that would strike that side would be nearly three. If a weir pens up five feet of water for a mile the water becomes stagnant, while it fills up to the weir; but if a fresh should come it would not produce any impediment to its passing over an oblique weir.

(To be continued.)

MISCELLANEA.

Daguerréotype Portraits.—A new discovery was communicated at the last sittings of both the Royal Society of London and the Institute of France in Paris, which is one of the most important improvements made in the Daguerréotype process, particularly when applied to the art of taking portraits. Mr. A. Claudet is the inventor of this discovery, which consists in the combination of chlorine, with the usual preparation. It is sufficient to expose the plate for one or two seconds to the vapours of that gas, to render it so sensitive to the effect of light, that the time of exposure in the camera obscura is shortened from 4 or 5 minutes to 10 or 15 seconds. This result must be of the greatest importance in taking likenesses, as the great difficulty in getting a person to sit immoveable for so long a period as was formerly required, always acted as a serious obstacle. Mr. A. Claudet is entitled to the warmest acknowledgments for his invaluable discovery, and for having been liberal enough to communicate it to the public. We understand that the inventor is carrying on his process at the Adelaide Gallery, and that his likenesses are exquisitely executed.

The Princess Royal Steam Pleasure Boat.—On Wednesday June 9th, this newly-built pleasure boat, propelled by the Archimedes screw, made her first pleasure trip from Brighton to Arundel and back. She was very recently built on the Tyne (under the direction of Messrs. Bass, W. Catt, jun., and Collins, the committee of the owners) from which port she arrived on the 8th June, in the short space of 48½ hours, the distance being upwards of 400 miles. She is of the following dimensions: length of keel 81 feet, breadth of beam 17½ feet, depth of hold 10 feet, of immersion 6½ feet, tonnage 101 tons register. There are two engines each of 23 horse power, the screw is 5 feet diameter, 6 feet pitch, and 34 strokes of the engine making 170 evolutions is the regulated speed. The velocity of the boat is about 8 knots an hour (equal to about 9½ miles.)

Horsham.—The new church of St. Mark's (the first stone of which was laid in April 1840), was consecrated on the 3rd instant. It is in the early English style. The new school-room adjacent is also completed. Now the work is finished it is due to the architect, Mr. Mosely, and the builder, Mr. Darby, to say that both design and execution are highly creditable. Still, the continuation of the parapets the whole length of the building, and the adoption of stone in lieu of slate for the roof would have been decided improvements. Doubtless the *funds* influenced these matters. The church contains 900 sittings, and the cost, including gas fittings, boundary wall, and a few other extras, is less than £3500. It must, however, be stated that the ground was a gift, as was also the use of a stone quarry.

Faculty of Engineering in the University of Dublin.—The authorities of Dublin University seem to be anxious to aid in the present movement for extending instruction in the practical sciences, and have given notice of their intention to form a faculty of engineering in Trinity College. The faculties now are London, Durham, Glasgow and Dublin, and the schools Woolwich, Chatham, Sandhurst, Addiscombe, King's College, University College, Museum of Economic Geology, Putney, Durham College, Edinburgh Academy, Glasgow College, Dublin College, and the Mining School of the Royal Dublin Society.

Société des Architectes.—A Society of Architects is in progress of formation at Paris, on the model of the Institute here, which we hope it will worthily emulate.

Powers of Locomotive Steam.—A steam coach running at a moderate rate, which is about 21 miles per hour, would run over a distance of 500 miles per day of 24 hours, and at that speed would reach British India from London in about 8½ days—or Pekin in China in 11 days—or from Gibraltar to the Cape of Good Hope in 10 days—or from Quebec to Cape Horn in 17 days—or once round the globe in 51 days—or 7 times round the globe in one year—or a distance equal from the earth to the moon in about 16 months, or from the earth to the sun in 500 years.—*Greenock paper.*

Pompeii.—A search among the ruins of Pompeii, which took place lately, led to the discovery of a marble statue, a silver vase, and a quantity of gold, silver, and bronze medals, in a good state of preservation.

Locomotive for Common Roads.—A gentleman residing at Southwell, Dr. Calvert, has constructed a machine, which he purposes to call "The *Alternate*," because he rides or walks in turn according to the ascending or descending inclination of the road he travels. By merely rising from his seat, and throwing part of the weight of the body upon the hands placed on a guiding bar, he *walks* with less fatigue than he could do without the machine, especially where the ascent is not very steep. On descending he sits down and *rides* at his ease with considerable speed. The propelling action (the most powerful that can be exerted, and one of the most lasting is that of rowing. *Nottingham Journal.*

Paper from Asparagus.—We have pleasure in hearing that one of the most famous paper manufacturers, M. Diercks, of Ghent, has collected all the stalks of asparagus that come from the tables d'hôte and great houses of the town, in order to convert them into paper. Every evening two or three loads of these fibrous stalks are carried to the rolling mill, and thence to the stamping machine, which triturates them in the course of a few hours. The kind of paste which is thus produced does not require bleaching. It is put into a tub, and taken to the paper-making machine, from which it issues converted into excellent white paper, the expense of which is not half that of paper made from rags. We have no doubt that when this secret is once known, it will be eagerly appropriated by all large manufacturers. Asparagus mixed with the pulp of beet-root produces a kind of paper, which is even superior. —*La Fanal.*

A Steam Organ.—M. Lax, jun., has just invented a steam organ, which can be heard through the extent of a whole province. This instrument, consisting of vibrating plates of metal, is so regulated that it is acted on by steam of four or five atmospheres of pressure. These plates are merely very large steel bars, which can only be made to vibrate by very high pressure steam. This monster organ is fitted for popular solemnities and inaugurations of railroads. It may be placed upon a wagon in front of the engine, which will supply it with the same steam that moves the piston in the cylinders. The sound of this stupendous instrument would overpower the noise of the issuing steam, the working of the wheels, and the roaring of thunder.—*Le Fanal.*

Rope-making in America.—Mr. Buckingham gives the following description of the rope manufactory at Boston. "The ropewalk of the navy-yard is one of the finest I ever remember to have seen. It is nearly half a mile in length, two stories in height; it is built entirely of the same beautiful granite as that used in the construction of the dry dock, and is roofed with iron and slate. The window shutters are all cased with iron, and the whole is rendered fire-proof. Some very recent and excellent improvements have been introduced into the machinery here, by a native American engineer, Mr. Treadwell, by which a steam engine at one end of the building is made to furnish the requisite power for performing all the operations for rope-making, with very little aid from the labour of men, from the first combing of the hemp, and spinning it into threads, to the tarring and twisting the yarn, and the winding of the whole into the hawser or the cable required. I had seen some of the best ropewalks in England, both in the royal dock-yards, and in the private establishments of London, and other parts, but I remember nothing equal to this of Boston, either in the beauty and perfection of the building and the machinery, or the admirable uniformity of strain in every strand and every fibre in the rope produced; or the finished roundness, smoothness and flexibility of the bawsers and cables, of which several were submitted to our examination, both in progress and completed."

Steam Navigation on the Meuse.—One of the new steam-boats intended for the Liegeian Company of Navigation, was last week launched in the Meuse. It was towed as far as the railway to Val-Benoit, in order to put in the boiler. Without the boiler, and with the engine alone, the draught of water of the boat was 21 centimetres (8 inches); with the boiler it is 25 centimetres (10 inches). The engine, which is a low-pressure one, and according to the Jackson plan, weighs only 2,400 kilogrammes. It was constructed in the manufactory of Messrs. Derosne, Cail, and Co., at Charenton, near Paris. Excepting in England and on the Loire, there are not yet any engines like it. The engines of the steam-boats which were in operation last year on the Meuse, were considerably heavier. The vessel which has just been launched is 3 metres and 50 centimetres (11 feet) in depth, and 36 metres and 50 centimetres (118 feet) long. Every thing on deck is nearly finished, and it will soon be able to commence working. Great progress is made in the construction of the second vessel, and it will be ready for service in a short time after the first. It is estimated that the draught of these boats, with their load of fuel, will not exceed 35 centimetres (14 inches), while that of the former boats amounted to nearly 60 centimetres (24 inches); we are, therefore, induced to hope that steam navigation, unless when the waters are excessively low, may henceforth be generally adopted on the Meuse.—Another steam-boat of iron is now constructing in the manufactory of M. Petry, an engineer, at Grevegnée-les-Liége. Persons experienced in the art of boat-building, who have had opportunities of seeing this fine vessel, consider that the country has not produced any equal to it.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM 27TH MAY, TO 25TH JUNE, 1841.

Six Months allowed for Enrolment.

GEORGE BENT OLLIVANT and ADAM HOWARD, of Manchester, millwrights, for "*certain improvements in cylindrical printing machinery for printing calicoes and other fabrics, and in the apparatus connected therewith, which is also applicable to other useful purposes.*"—Sealed June 5.

JOHN MEE, of Leicester, framesmith, for "*improvements in the manufacture of looped fabrics.*"—June 5.

WILLIAM HANNIS TAYLOR, of Lambeth, Esq., for "*certain improvements in propelling machinery.*"—June 5.

JOSEPH GIBBS, of the Oval, Kennington, civil engineer, for "*certain improvements in roads and railways, and in the means of propelling carriages thereon.*"—June 5.

MILES BERRY, of Chancery-lane, patent agent, for "*certain improvements in machinery or apparatus for ruling paper.*" (A communication.—June 5.

JAMES COLLEY MARCH, of Barnstaple, surgeon, for "*certain improved means of producing heat from the combustion of certain kinds of fuel.*"—June 8.

HENRY RICHARDSON FANSHAW, the younger, of Hatfield-street, Surrey, chemist, for "*improvements in curing hides and skins, and in tanning, washing, and cleaning hides, skins, and other matters.*"—June 10.

JOHN GEORGE BODMER, of Manchester, engineer, for "*certain improvements in machinery for propelling vessels on water, parts of which improvements apply also to steam engines to be employed on land.*"—June 10.

EDWARD HAMMOND BENTALL, of Heybridge, Essex, iron-founder, for "*certain improvements in ploughs.*"—June 10.

ROBERT ORAM, of Salford, Lancaster, engineer, for "*certain improvements in hydraulic presses.*"—June 12.

JAMES WILLS WAYTE, of the "Morning Advertiser" office, Fleet-street, engineer, for "*certain improvements in machinery or apparatus for letter-press printing.*"—June 12.

JOHN ANTHONY TIELENS, of Fenchurch-street, merchant, for "*improvements in machinery or apparatus for knitting.*" (A communication.)—June 12.

GEORGE CLAUDIUS ASH, of Broad-street, Golden-square, dentist, for "*improvements in apparatus for fastening candles in candlesticks.*"—June 12.

EDWARD PALMER, of Newgate-street, gentleman, for "*improvements in producing printing surfaces, and in the printing china, pottery, ware, music, maps, and portraits.*"—June 12.

EZEKIEL JONES, of Stockport, mechanic, for "*certain improvements in machinery for preparing slubbing, roving, spinning, and doubling cotton, silk, wool, worsted, flax, and other fibrous substances.*"—June 12.

ALEXANDER HORATIO SIMPSON, of New Palace-yard, Westminster, gentleman, PETER HUNTER IRVIN, and THOMAS EUGENE IRVIN, both of Charles-street, Hatton-garden, philosophical instrument makers, for "*an improved mode of producing light, and of manufacturing apparatus for the diffusion of light.*"—June 17.

THOMAS WALKER, of North Shields, engineer, for "*improvements in steam engines.*"—June 18.

WILLIAM PETRIE, of Croydon, gentleman, for "*improvements in obtaining mechanical power, which are also applicable for obtaining rapid motion.*"—June 19.

JOHN HAUGHTON, of Liverpool, clerk, master of arts, for "*improvements in the method of affixing certain labels.*"—June 19.

JAMES HENRY SHAW, of Charlotte-street, Blackfriars, jeweller, for "*improvements in setting wheat and other seeds.*"—June 19.

SIR SAMUEL BROWN, knight, of Netherbyers-house, Ayton, Berwick, for "*improvements in the means of drawing or moving carriages and other machines along inclined planes, railways, and other roads, and for drawing or propelling vessels in canals, rivers, and other navigable waters.*"—June 19.

JOHN GEORGE TRUSCOTT CAMPBELL, of Lambeth-hill, Upper Thames-street, grocer, for "*improvements in propelling vessels.*"—June 19.

JOSEPH GAUCI, of North-crescent, Bedford-square, artist, and ALEXANDER BAIN, of Wigmore-street, Cavendish-square, mechanist, for "*improvements in inkstands and inkholders.*"—June 21.

MILES BERRY, of Chancery-lane, patent agent, for "*a new or improved engine, machine, or apparatus for producing or obtaining motive power by means of gases or vapours produced by combustion.*"—June 23.

WILLIAM WALKER, the elder, of Standish-street, Liverpool, watch-finisher, for "*an improvement or improvements in the manufacture of the detached lever watch.*"—June 23.

GEORGE THOMAS DAY, of Upper Belgrave-place, Pimlico, gentleman, for "*an improved apparatus for creating draft applicable to chimneys and other purposes.*"—June 23.

JOHN HENRY LE KEUX, of Southampton-street, Pentonville, for "*an improvement in line engraving, and in producing impressions therefrom.*"—June 23; two months.

JOHN GOODWIN, of Cumberland-street, Hackney-road, piano-forte maker, for "*an improved construction of piano-fortes of certain descriptions.*"—June 23; two months.

JAMES SIDEBOTTOM, of Waterside, Derby, manufacturer, for "*certain improvements in machinery for apparatus.*"—June 23.

WILLIAM CHESTERMAN, of Burford, Oxford, gentleman, for "*improvements in filtering liquids.*"—June 23.

ROBERT STEPHENSON, of Great George-street, Westminster, civil engineer, for "*certain improvements in the arrangement and combination of the parts of steam engines of the sort commonly called locomotive engines.*"—June 23.

JOHN LEE STEVENS, of King Edward-street, Southwark, general agent, and JOHN KING, of College Hill, printer, for "*certain improvements in candlesticks and other candle holders.*"—June 25.

TO CORRESPONDENTS.

Mr. Mushet's papers; and Mr. Davies and Mr. Ryder's reply to Mr. Perkins' answer, that appeared in last month's Journal, were not received until the latter part of the month, they will appear in the next Journal.

M. Q.'s communication will appear next month—tracings will be returned when required.

"The Mammoth" is to be worked by the Screw, unless new orders have been lately given to the contrary.

We must beg of our American correspondents not to forward Pamphlets by Post, we have had several demands upon us for 5s. and 6s. postage for each.

A lengthened abstract of Mr. Hood's excellent paper "on the Properties and Chemical Constitution of Coal," has already been given in the Journal, and the paper besides has appeared in another periodical.

Works received and will be noticed next month—Mr. Ranken's Patent Wood Pavement, Report on "the Improvement of the Navigation of the Forth betwixt Stirling and Alloa." "Irish Railways," Mr. Sopwith's description of Geological Models, and Mr. Williams's work on the Combustion of Coal, 2nd edition.

Communications are requested to be addressed to "The Editor of the Civil Engineer, and Architect's Journal," *No. 11, Parliament Street, Westminster.*

Books for Review must be sent early in the month, communications on or before the 20th (if with drawings, earlier), and advertisements on or before the 25th instant.

Vols. I, II, and III, may be had, bound in cloth, price £1 each Volume.

ERRATA.

In Mr. Clark's communication "*On the Action of Central Forces*," in the last month's Journal, page 182, 2nd column, 31st line from bottom, for $AC - AB$, read $AC = AB$. And page 183, column one, line 29, for $x = \frac{m}{r}$ read, $x = \frac{v^2}{r}$.

IRON ROOF OVER THE RAILWAY STATION OF THE VERSAILLES RAILWAY AT PARIS.

Fig. 1.—Section of upper part of Roof.

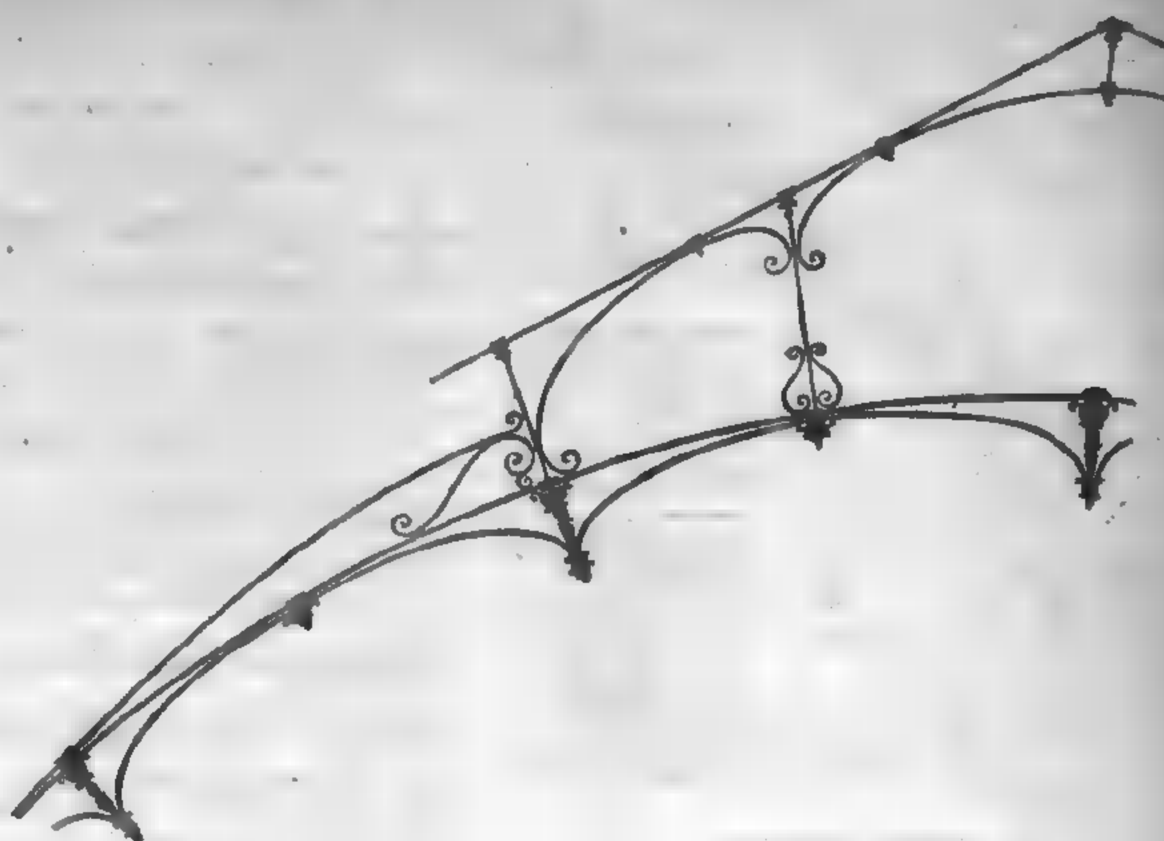


Fig. 3.—View of Railing supporting Skylight.

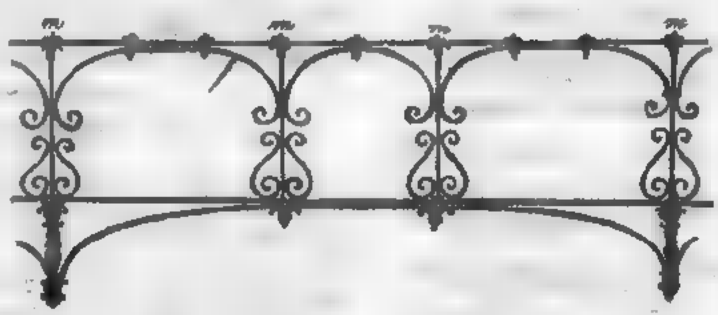


Fig. 2.—Section of the lower part of Roof.

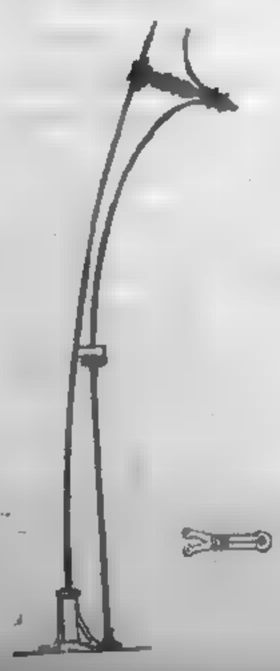


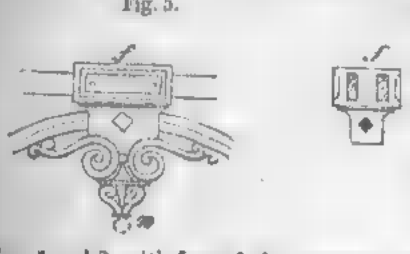
Fig. 5.—Plan of Rafters.

RAILWAY STATIONS.

The Revue Generale contains a description of several Railway Stations both in England and on the Continent, illustrated with details of their construction, from which we extract the following information relative to the Paris Station of the *Left Bank Versailles Railway*, situated near the barrier of Maine.

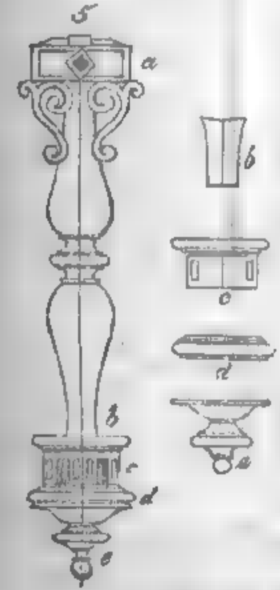
The terminus of the railway is on an embankment 23 feet high, which offers serious impediments to the construction of buildings, turn tables, and other works requiring solidity. The terminus consists of three ways with a platform on each side for the passengers on their arrival and departure. The whole of this was covered over with a semicircular roof of iron, which fell down soon after its construction, during a hurricane on the 16th of September last. The semicircular form without any stays forming direct angles is at all times a bad mode of constructing buildings, where they are subject to the powerful action of the wind, as its force impinging upon any part is transmitted through the whole, and when successive gusts of wind are continued, this transmission of the force becoming more and more formidable like a wave in a tempest, must in the end lead to the destruction of any building that is built of such slender materials as the one now before us. The roof possesses considerable ingenuity in its construction, for its lightness and elegance of its form, we shall therefore notwithstanding its failure, proceed to give some account of its construction.

Fig. 5.



The roof is of a semicircular form 164 feet long, and consists of 13 main ribs or arches placed 12 ft. 6 in. apart in the clear, 10 of which were 57 feet span, and three at the extreme end of the station 70 feet span. A section of the roof is represented in figs. 1 and 2, with four of the tangential curvilinear stays omitted. The main ribs spring from an upright cast iron base (fig. 2,) standing on the timber piles which carry the passengers promenade platforms, these piles are tied across the railway transversely at about 4 feet below the top of piles, or 3 feet below the surface of the rails by strong wrought iron ties, to prevent them spreading. The ribs are composed of 5 bars of wrought iron up to the top of the column, fig. 2, the two external bars ½ inch by inch, the two next ½ by 1½ inch, and the centre 1½ by 2 inches, all bolted together; above the column and up to about two-thirds the height they have only 4 bars, omitting the centre, and the remainder have only the 2 external bars. These ribs are strengthened by tangential curvilinear stays, consisting of wrought iron bars ¾ inch square placed diagonally and secured in the centre by the ornamental coupling *n*, fig. 5, and at each end by the pendant *x*, shown more in detail in fig. 6, and secured to the main rib. There are also similar tangential curvilinear stays springing from the same pendants at right angles to carry the purlin bars as shown in the lower part of fig. 3, for the support of the rafters and covering, the lower tangential stays abut upon the top of the wrought iron column 1½ inch diameter (fig. 2). The pendants (fig. 6,) consist of a cast iron baluster, the 2 bars of the main rib passing through the head (*a*), and also at right angles the purlin bar. The 4 ends of the tangential bars are secured in the holes at the 4 angles of the base *c*, which is hung up to the bars of the rib by a nut and screw bolt passing through the centre of the pendant; the *d* an *c′* shows the position of these holes, that in the centre receiving the bolt just described, and those at the 4 angles the tangential stays; the drop *c*, with the collar *d*, is fastened on to the top of the pendant and conceals the bolts, the bottom part of the baluster fits in with the conical shaped end (*b*) into the embrasure (*e*).

Fig. 6



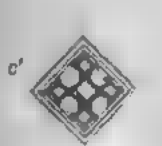


Fig. 7.

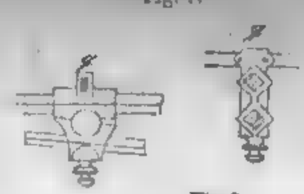
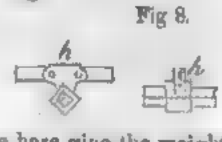


Fig 8.



The purlin bar and the curvilinear stays were secured by the coupling *g*, fig. 7, and fig. 8 shows the coupling of the purlin and the rafter *h*, which were of wrought bars 3 by ⅜ inch placed 18 inches apart, as shown in fig. 4. The covering was of galvanized sheet iron laid with a folded seam similar to zinc.

The upper part of the roof was covered entirely by a skylight, laid to an angle of 25°, the lower part was supported by the light ornamental iron work shown in fig. 3, supported by the tangential stay bars.

We here give the weights of the principal parts.

Base of the column	5 lb.
Capital	9¼ lb.
Pendants of cast iron	26 lb.
Great S shaped guard of the lantern	36½ lb.
The parts *m*	10¾ lb.
n	7¾ lb.
o (cast iron)	7¼ lb.
p	3¾ lb.
h	¾ lb.

The total weight of the casting of the roof was 5 tons 6 cwt.

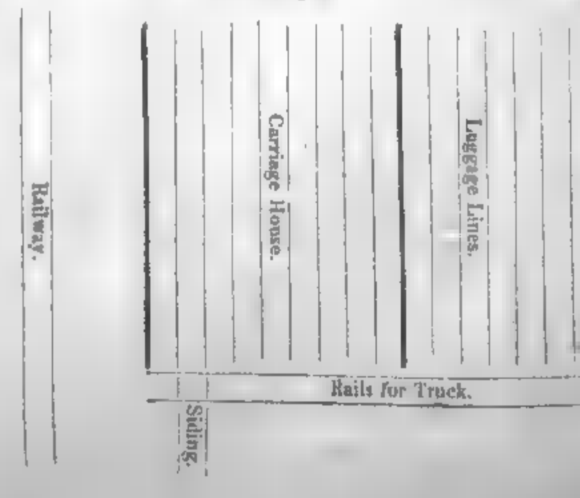
That of the other iron work 13 tons 5 cwt.

The total cost including painting and glazing was 25,000 francs, (1000*l*.), and as there were about 1000 square yards of surface, that gives 1*l*. per square yard covered, undoubtedly an exceedingly low price.

It will be seen from the preceding description what a great number of cast iron pendants and couplings compose this roofing, but at the same time that the different shapes are not numerous, and that the models are few. In wrought iron in order to obtain this variety of shape, it would have been requisite to have forged each piece separately, and to have had much manual labour. It will be further perceived that all the pieces are simply cut in lengths, without being reforged or filed. The iron on coming from the forge, is bent cold according to the form required, and then fixed in the cast iron pendants by means of bolts, so that it is not necessary to employ iron of superior quality that can be worked hot; it is only necessary that it should not be cold short. It is this arrangement to which we principally wish to call attention, as it is the reason which has induced us to publish the preceding description, as an instance of an iron roof easily put together and composed of a minimum weight of cast and wrought iron. It will be seen that such work can be made at a distance and then put up on the spot. It is only necessary to send the pendants and couplings, and the bars of rough iron, which are to form the roof, and which can be cut up on the spot, and bent according to circumstances. As the coupling pieces are of cast iron, ornaments can be introduced in the casting, and an elegant appearance given without much expense. With these advantages had M. Fauconnier designed it with lines so as to have formed geometrical figures of fixed position, we have no hesitation in saying that it would have been a most remarkable work.

At the same station for the purpose of communicating between the main rails and the carriage house, which is parallel to them, a siding is carried from the main line to the front of the carriage house, as shown in fig. 9. The latter contains four lines of ways running from

Fig. 9.



from front to rear, and outside of it are five more lines of way for the luggage trucks. Along the front of the carriage house, and at right angles with the rails is a pair of rails laid to a gauge of 7 ft. 4 in., and 9 inches below the lines of way, upon which runs a carriage, shown in figs. 10 and 11. On the top of this carriage, and on a level with the

Fig. 10, Plan of Truck.

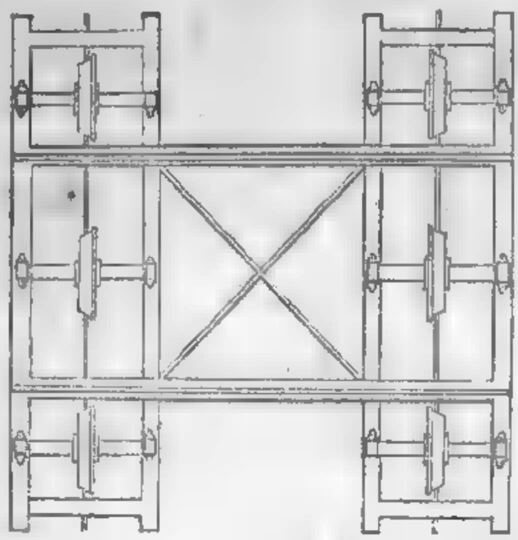
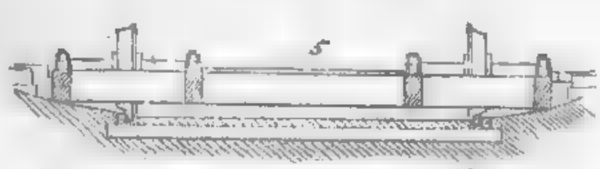
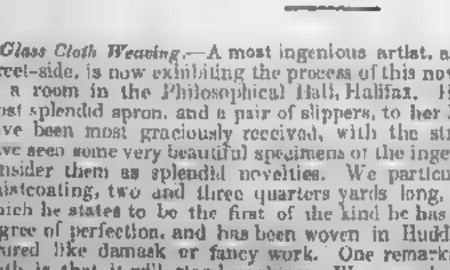


Fig. 11, Section of Truck.



rails of the main line are corresponding rails supported on timber framing, which is suspended to the axles of six cast iron wheels, 20 inches diameter. These wheels run on the 7 ft. 4 in. gauge for the purpose of removing the carriage or truck which is put upon the frame to any pair of the reserve rails in the carriage-house. This saves the trouble and expense attendant upon turn tables opposite to each pair of rails.

Fig. 12.



The engine house is a polygonal building containing twelve lines of way, in the middle of which is a turn table communicating with the whole. The construction of the points is shown in the annexed figure 12.

Glass Cloth Weaving.—A most ingenious artist, a Mr. Barker, from Ossett-street-side, is now exhibiting the process of this novel species of manufacture, in a room in the Philosophical Hall, Halifax. He has lately forwarded a most splendid apron, and a pair of slippers, to her Majesty the Queen, which have been most graciously received, with the strongest approbation. We have seen some very beautiful specimens of the ingenious inventor's skill, and consider them as splendid novelties. We particularly noticed a piece of waistcoating, two and three quarters yards long, and half a yard in width, which he states to be the first of the kind he has been able to bring to any degree of perfection, and has been woven in Huddersfield. It is beautifully figured like damask or fancy work. One remarkable circumstance in glass cloth is that it will stand washing. We were shown a piece of pure white, which has six times undergone that process. We hope the ingenious and persevering man who has already spent two years and a half in bringing his invention to a state fit to meet the public eye, will reap his reward for his invention.—*Halifax Guardian.*

ON THE ECONOMY OF FUEL IN LOCOMOTIVES CONSEQUENT TO EXPANSION AS PRODUCED BY THE COVER OF THE SLIDE VALVE.

SIR—With a view to economy of fuel, locomotives are now generally constructed so that the slide valve shall have what engineers call "cover on the steam side," the effect of which is, that steam is admitted to the cylinder during only a part of the stroke of the piston, and during a part of the remainder that steam by expanding to occupy a greater volume propels the piston; which expanding increases the work performed by a given quantity of steam to an extent depending on the ratio of that part of the stroke, during which the steam is admitted to the cylinder, and that part of it during which the steam is expanding; and as the consumption of fuel is dependent on the work performed by a given quantity of steam, an analytic investigation of the cover of the slide valve is the object of the following.

In the figure* let F′ G, represent the connecting rod, F′ E the engine crank, E A′ the eccentric crank, F E the engine crank when the piston commences its stroke, and E A the corresponding position of the eccentric crank, B C, D C valve levers. Put E A′ $= a$, E F′ $= d$, cover of valve $= c$, lead of valve $= l$, B C $=$ D C. To diminish complication neglect the radiation of the eccentric rod and connecting rod, which may be done without sensible error, since their length is great in proportion to the lengths of the cranks.

Draw L E perpendicular to E B, and any angle L E A has its sine proportional to the distance that the valve is from its position when L E A $= o$. When the piston is commencing its stroke the valve is open, the quantity (l), and therefore it has travelled the quantity ($l + c$) from its position when L E A $= o$; hence $a \times$ sin. L E A $= l + c$

$\therefore$ sin. L E A $= \frac{l+c}{a}$, and cos. L E A $=$

$$\sqrt{\left(1 - \frac{(l+c)^2}{a^2}\right)}$$

Again, if the engine crank travels over any angle (φ) from its position, F E the descent or progress (y) of the piston is equal to $d \times$ versin φ, $\therefore$ cos. $\varphi = 1 - \frac{y}{d}$, and sin $\phi = \sqrt{\left(\frac{2y}{d} - \frac{y^2}{d^2}\right)}$. The travel ($x$) of the valve corresponding to the travel (y) of the piston, is equal to (a sin. (L E A $+ \varphi$) $- a$ sin. L E A), $\therefore \frac{x}{a} =$ sin. L E A cos. $\varphi +$ cos. L E A sin. $\varphi -$ sin. L E A, and by substituting for the functions of the angles their values found above, and reducing we get

$$x^2 + 2x(l+c)\frac{y}{d} = a^2\frac{2y}{d} - a^2\frac{y^2}{d^2} - (l+c)^2\frac{2y}{d},$$

an equation expressing the relation of (x) and (y) in terms of known quantities.

When the piston begins its stroke the valve is a little open, and steam continues to enter until the valve in its retrograde motion shuts the passage; expansion then commences and continues until the eduction passage is opened. When the eduction passage is opened on one side of the piston it is shut on the other, which gives rise to the compression of steam on the educted side of the piston, and this compression continues until the valve opens for the lead of the next stroke.

In figure let A B C D be a steam cylinder, stroke $=$ A D $= 2\,d$, $a' =$ distance from commencement of stroke to commencement of expansion, $b =$ distance from commencement of stroke to end of expansion; $c' =$ distance from commencement of stroke to position of piston when the valve opens for the lead of next stroke. To find by the above equation the travel of the valve corresponding to the travel (a') of the piston substitute $x = -l$, for the travel corresponding to (b) $x = -(l + c)$, and

* The figure is not quite correct; the line should be drawn from f' to e and not from f' to a'.

for the same in relation to (c') $x = -(l + 2c)$. And we have

$$x = -l \text{ and } y = a' = \frac{d(a^2 - lc - c^2) + d\sqrt{(a^2 - lc - c^2)^2 - a^2 l^2}}{a^2} =$$

$$d(1 - lc - c^2) + d\sqrt{\left\{(1 - lc - c^2)^2 - l^2\right\}}. \quad \text{When } a = 1$$

$$x = -(l + c) \quad y = b = \frac{a^2 d + d\sqrt{a^4 - a^2(l+c)^2}}{a^2} = d + d\sqrt{1 - (l+c)^2}$$

$$x = -(l + 2c) \quad y = c' =$$

$$\frac{d\left\{a^2 + lc + c^2\right\} + d\sqrt{\left\{(a^2 + lc + c^2)^2 - a^2(l + 2c)^2\right\}}}{a^2} =$$

$$d(1 + cl + c^2) + d\sqrt{\left\{(1 + cl + c^2)^2 - (l + 2c)^2\right\}}$$

Having now found the values of $(a'$ b and $c')$, we must next find the effect gained by the expansion of the steam from $(a'$ to $b)$, and the effect lost by the compression of the steam from $(b$ to $c')$. But expansion may take place in two ways, the operations of which are quite distinct, first, the cylinder may remain of the same volume and the steam be increased in pressure before entering them; or, the cylinders may be enlarged and the pressure of the steam be constant, which is the plan virtually adopted in locomotives; for those of them that do not work by expansion when properly constructed, are so made that their cylinders are not capable of consuming a greater volume of steam than the boiler can furnish of the greatest safe pressure.

The eduction passage being shut by the time that the piston arrives at the end of (b), saves, or at least prevents from flying to the atmosphere a quantity of steam of a pressure (t), that fills $(2d - b)$ of the cylinders, which at a pressure (p) would fill $\frac{(2d-b)t}{h}$ of the cylinders hence when the steam is cut off at (a'), there is only admitted so much fresh steam as fills $(a' - \frac{(2d-b)t}{h})$ and since the quantity of fresh steam admitted must (whatever the expansion is) be constant, we have $s\left(a' - \frac{(2d-b)t}{p}\right) = 2d \times 1$, $\therefore s = \frac{2dp}{a'p - 2dt + bt}$, (s) being the area of the piston.

Again in figure let (x) be any portion of the stroke greater than (a), and less than (b), and let p' be the pressure into which the steam has expanded at the end of (x) then $x : a' :: p : p'$, $\therefore p' = \frac{ap}{x}$ $\therefore$ effective working pressure $= \frac{ap}{x} - t$.

$\therefore$ differential of work performed $= d$ efficiency $= s\left(\frac{ap}{x} - t\right) dx$,

$\therefore$ efficiency in part (b) of the stroke $= s\,ap\left(\log\frac{b}{a} + 1\right) - stb$.

Again, for the effect of compression caused by the shutting of the eduction passage let (x) (measuring from D C) be any portion of the stroke between $(b$ and $c)$, and (p') the pressure, to which the confined steam has been compressed, then $x : 2d - b :: t : p'$ $\therefore p' = \frac{(2d-b)t}{x}$, $\therefore$ effective working pressure $= \frac{(2d-b)t}{x} - t$ $\therefore d$ efficiency $= \left(\frac{(2d-b)t}{x} - t\right) s\,dx$, $\therefore$ whole effect of compression $=$

$$st(2d - b)\left\{\log.\frac{2d-b}{2d-c} - 1\right\} + s(2d - c)(p + t.)$$

By deducting the effect of compression from the efficiency of the part (b) of the stroke, we have whole work performed $=$

$$s\,a'p\left(\log.\frac{b}{a'} + 1\right) - stb - st(2d - b)\left\{\log.\frac{2d-b}{2d-c} - 1\right\}$$

$- s(2d - c)(p + t)$. Put $2d = 1$, $t = 1$ and (p) is then expressed in multiples of (t). $\therefore$ whole work performed $=$

$$s\,a'p\left(\log.\frac{b}{a'} + 1 - sb - s(1 - b)\left\{\log.\frac{1-b}{1-c} - 1\right\}\right)$$

$- s(1 - c)(p + 1)$.

$$\text{But } s = \frac{p}{a'p - 1 + b}$$

$\therefore$ Whole work performed $= \frac{p}{a'p + b - 1}$ multiplied into

$$\left\{a'p\log.\frac{b}{a'} - (l - b)\log.\frac{1-b}{1-c} + a'p - 2b - p + pc + c.\right\}$$

An expression for the work performed by a unit of volume of steam, formed of known quantities, or rather of quantities which become known when (l) the lead, and (c) the cover of the valve are given.

Let the safety valve be so loaded that (p) is equal to (s), and let the lead (l) of the slide valve be nothing, and the cover (c) be nothing. Then $a' = 1$, $b = 1$, $c' = 0$, $\therefore$ whole work performed $= p - 1 = 4$, which is exactly what another mode of proceeding gives for when the valve has no cover and no lead, the work performed is evidently $= 2d(p - t)s$. But $2d = 1$, $t = 1$, and when the valve gives no expansion $s = 1$, therefore work performed $= p - 1 = 4$.

Again, let the lead (l) be equal to $\frac{1}{8}$ of the breadth of the port, and the cover (c) equal to $\frac{1}{4}$ of the breadth of the port. And then

$a' = 0{\cdot}888$ $\quad b = 0{\cdot}9545$ $\quad c' = 0{\cdot}992$ $\quad \therefore$ whole work performed $= 4{\cdot}2376$.

Again, let $l = \frac{1}{6}$ breadth of port, $c = \frac{1}{2}$ breadth of port, and then
$a' = 0{\cdot}656$ $\quad b = 0{\cdot}878$ $\quad c' = 0{\cdot}99$ $\quad \therefore$ whole work performed $= 4{\cdot}8966$.

Again, let $l = \frac{1}{8}$ breadth of port, $c = \frac{3}{4}$ breadth of port, and then
$a' = 0{\cdot}2884$ $\quad b = 0{\cdot}7$ $\quad c' = 0{\cdot}975$ $\quad \therefore$ whole work performed $= 7{\cdot}1$.

Again, $l = \frac{1}{100}$ breadth of port, $c = \frac{3}{4}$ breadth of port, and then
$a' = 0{\cdot}43$ $\quad b = 0{\cdot}825$ $\quad c' = 0{\cdot}999$ $\quad \therefore$ whole work performed $= 4{\cdot}97$.

Hence the following conclusions:—In a locomotive in which the stroke of the cylinder is 18 inches, and breadth of port $1\frac{1}{2}$ inches, if the work it performs with a ton of coke when the valve has no cover be called 1; then by giving the valve $\frac{1}{4}$ of an inch of lead, and $\frac{3}{8}$ of an inch of cover, the steam will be cut off at 15·98 inches from commencement of stroke, and the work performed by a ton of coke will be 1·0594.

Again, by giving the valve $\frac{1}{4}$ of an inch of lead, and $\frac{3}{4}$ of an inch of cover, the steam will be cut off at 11·8 inches from commencement of stroke, and the work performed by a ton of coke will be 1·2241.

Again, by giving the valve $\frac{1}{4}$ of an inch of lead and $1\frac{1}{8}$ inches of cover, the steam will be cut off at 5·2 inches from commencement of stroke, and the work performed by a ton of coke will be 1·75.

Again, by giving the valve $\frac{1}{100}$ of the breadth of the port of lead, and $1\frac{1}{8}$ inches of cover, the steam will be cut off at $7\frac{3}{4}$ inches from commencement of stroke, and the work performed by a ton of coke will be 1·242.

In the two last examples the cover of the valve is the same, but in the latter the lead is much less than in the former, which has diminished the efficiency of a ton of coke from 1·75 to 1·242, or nearly in the ratio of 3 to 2; and if the lead was still a little less the advantage gained by the cover would be altogether neutralized. Hence it appears that the lead is an important feature in the construction of the slide valve, and might be a good subject of enquiry as to what relation it ought to bear to the cover so as not to interfere with the operation of expansion.

I am, Sir, your obedient servant,

J. G. LAWRIE.

Cartsdyke Foundry, Greenock,
June 27, 1841.

N.B.—Should you consider this letter worthy of insertion in your Journal, I shall probably request insertion of another in continuation of the same subject, in which the lead will come under consideration.

J. G. L.

REMARKS ON MR. DREDGE'S SUSPENSION BRIDGE.

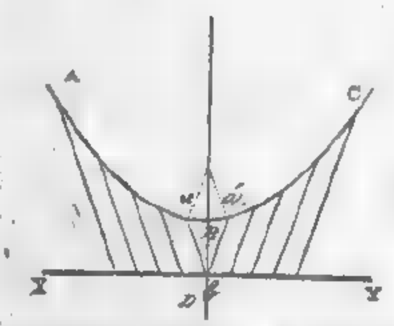
SIR—Feeling some interest in the subject of suspension bridges, I was gratified to find in a recent number of your instructive publication, a description of Mr. Dredge's newly invented suspension bridge, represented as offering such superior advantages, in all the essential particulars of strength, durability, and economy of construction. At the same time, however, I was somewhat disappointed when, having perused the article in question, I found that no attempt had been made to demonstrate the possession of such desirable qualities, by a reference to those well known principles and laws which govern the forces to which a suspension bridge is subject, and not having subsequently seen in the Journal or other publications, any such investigation of the subject, I am induced to forward to you the few remarks which follow, in

the hope that you may think them deserving of a place in your forthcoming number.

The two characteristic features of Mr. Dredge's bridge appear to be the unequal thickness of the chains which taper from the middle point of the curve to its extremities, and the inclined position of the suspension rods.

A chain whose thickness is equal throughout being suspended from its extremities, assumes the form of a curve which has received the name of the Catenarian curve; the tension to which the chain is subject by its own weight, varies as the secant of the angle made by the tangent on any point, with a horizontal line, or, which is the same thing, as the secant of the angle contained by the tangent and ordinate. It is obvious, therefore, that the tension will be least at the lowest point of the curve, and increase towards the points of attachment, where it will be a maximum. In a chain of equal thickness its strength cannot therefore be proportionate to the stress to which it is subject, and it therefore naturally occurs that the chain should not be of equal thickness throughout, but be increased in sectional area from the lowest point of the curve to the highest. By mathematical analysis, the form of chain has been determined whose sectional area is always proportional to the tension; and a chain constructed upon this principle has, I believe, been actually adopted for the large suspension bridge erecting over the Avon by Mr. Brunel.

The idea of a chain of varying thickness is not therefore *new*, and as regards Mr. Dredge's bridge, the utility of the form of chain he has adopted appears to depend upon whether the sectional area varies as the tension at each point. Considering the chain in the first instance, as simply affected by its own weight, this point would be determined by comparing its form with that in which it is known the sectional area varies as the tension. I have not at this moment with me the means of making the comparison, but it is evident that if the two forms are identical, there is no *novelty* in this part of the invention, and if they are not, Mr. Dredge has proposed a form which is inferior to one that would always be employed when rendered proper from attendant circumstances. Except in large bridges it has not, however, been considered desirable to vary the thickness of the chain according to the tension, as the difference of thickness at different points is found too inconsiderable to merit attention. It seems, therefore, extremely probable that Mr. Dredge by varying the thickness of his chain in a very rapid ratio has far exceeded the increased thickness required by the tension.



Abstracting now for the sake of argument, the effect produced by the weight of the chain itself, and regarding only that occasioned by the tensions of the rods, it will be observed that these tensions are much increased by the inclined positions which the rods are made to assume. This is illustrated in the figure. A B C is the chain, X Y the horizontal platform, and a b, a' b, &c. the suspension bars. Let us suppose that the tension of the bars has been adjusted so as to be equal for all, and that the weight of the platform is known. If it be homogeneous in its structure, the centre of gravity will be at b, and the weight may be conceived as a force B D, acting in a vertical direction through this point. Each of the pairs of forces acting along the rods a b, a' b, &c., will have a resultant acting in the direction D B, opposite to that in which gravity acts. These resultants will also be equal to one another, and, supposing the platform suspended from two chains, their sum will be a force equal in magnitude (though opposite in direction) to half the force B D, the weight of the platform. Hence if this weight be given, we obtain the resultant of each pair of forces acting along oppositely inclined rods, by dividing half this weight by half the number of rods attached to one chain. Let the angle made by the rods with the vertical be θ, w half the weight of the platform, and n the number of rods, then the resultant of each pair of forces $= \frac{w}{\frac{1}{2}n}$.

And b the tension of each rod is $\frac{1}{2} \times \frac{w}{\frac{1}{2}n} \times \frac{1}{\cos.\theta} = \frac{w}{n\cos.\theta}$. Hence

$b \propto \frac{1}{\cos.\theta} \propto \sec.\theta$, and is consequently least when $\sec.\theta$ is least, *i. e.* when $\sec.\theta = 1$, or the rods are vertical. This arrangement, then, appears disadvantageous, since it not only requires that the rods should be made of increased size to resist the increased tension to which they are exposed, but subjects also the chain to increased pressure from the rods in the ratio of $\sec.\theta : 1$.

Although the forces acting upon the two halves of the chain are inclined in opposite direction, it will be observed that the two halves are precisely similar, for if we imagine one-half to revolve round the axis B D, till the plane in which it is situated, coincides with the plane of the other half, the suspension rods of the two halves will exactly coincide, and consequently as the forces produced by them are equal, coincident in direction, and have similar points of application, the curves produced will be identical in all respects. Being produced by equal and parallel forces uniformly distributed along the curve, they belong to a Catenary whose ordinate is at right angles to the directions of the rods. Hence the tension caused by the action of the rods varies according to the law already stated, and if it be required to equalize the sectional area and tension of the chain, it must be constructed of the form already determined for the Catenarian Curve. Whether, then, we consider the effect of the weight of the chain itself, or the pressures produced by the suspension rods, the chain should be constructed upon precisely the same principles as in the ordinary suspension bridges. For these reasons I cannot but regard the plan proposed by Mr. Dredge as inferior to the ordinary method of construction, and I have accordingly, a contrary opinion having been maintained in your pages, ventured to offer these remarks to the consideration of your readers.

I am, Sir, your's obediently,

G. F. F.

Sandon Bury, July 14, 1841.

MR. PARKES' NEW THEORY OF THE PERCUSSIVE ACTION OF STEAM.

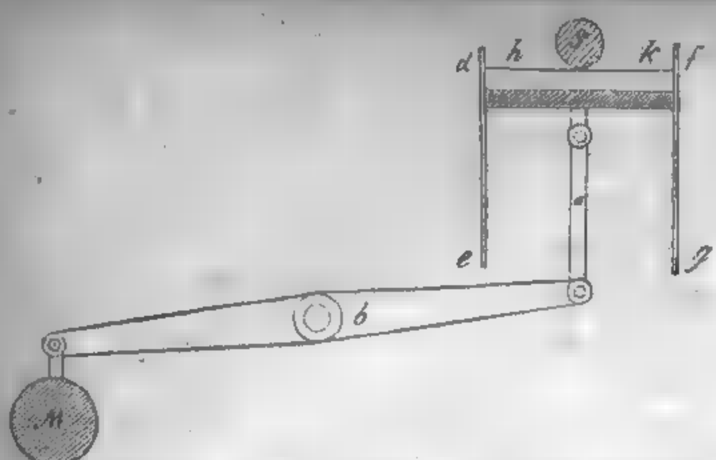
In this highly enlightened age, when long established theories crumble to dust under the all-searching glance of modern science, and the discoveries of our fathers, eclipsed by the surpassing splendour of the productions of modern genius, hide their diminished heads, it would perhaps be a mark of weakness of intellect to express astonishment at any new doctrine, however contrary it may be to our preconceived notions, or apparently so to the fundamental laws of nature. If, then, we were not surprised, at least our interest was excited in a high degree by the perusal of Mr. Josiah Parkes' Paper "on the Action of Steam in Cornish Single Pumping Engines," published in the Transactions of the Institution of Civil Engineers, Vol. 3, Part 4, wherein he developes, or rather announces a new principle of Action of Steam in Cornish Engines, which seemed at the first glance to point out a means of increasing almost indefinitely the dynamic effect of steam in steam engines; though why he considers it to operate in these engines only we know not—we are of opinion, that, if it obtains in them, it should obtain *à fortiori* in Locomotives, where the density and velocity of the steam entering the cylinder are so much greater. This new Principle is denominated by its discoverer the *Percussive Action of Steam*, and is announced in the following words, page 268:

"Steam, in its action on the piston of an engine, has hitherto been considered as simply exerting elastic force."

"Steam, however, possesses another important property, equally inherent in its nature with pressure and expansibility. This property is the velocity and consequent momentum due to steam of high elasticity; a force which comes into play under the peculiar conditions of a Cornish engine. The velocity of steam, in passing from a dense into a rarer medium, is immense; and the momentum of this steam must be very considerable. On the sudden and free communication effected between the cylinder and boiler of a Cornish engine, the steam in the cylinder receives an instantaneous action, proportionate, in amount, to the velocity of the entering steam, and this action, by the property of fluids, is transmitted to the surface of the piston. This action, thus transmitted to the piston, and due to the communication suddenly established between the highly elastic steam in the boiler, and the steam in the cylinder, may be likened, I conceive with great propriety, to the force of percussion; by which term I propose to distinguish it from the action of the steam's simple elastic force."

This force is illustrated in a note at the foot of the page by a comparison with the Pile-driving Machine and Hydraulic Ram; we think the following illustration much more appropriate.

Let d e f g in the annexed diagram represent the section of a cylinder, in which the piston p can move air-tight, let the latter be connected by a link a to one end of the vibrating beam b, a mass M being



suspended at the other end; further, let *h k* represent an inflexible circular plate fitting air-tight into the cylinder, but supposed to have no weight, and let there be a space *c* between this plate and the piston *p* filled with air of a given density.

The piston *p* being near the top of the cylinder, the circumstances are analogous to those of the Cornish single-acting engine just before the commencement of the working stroke, the air in the space *c* above the piston representing the cushion of steam against which the piston is brought to rest at the end of the return stroke, the beam *b* the balanced portion of the moving parts of the machinery, and the mass M the unbalanced portion.

In order to form an idea of the manner in which the momentum of the steam, admitted suddenly above the piston at the beginning of the stroke, is transferred to the latter, and thus increases the effect above what is due to the simple elastic force of the steam, let a mass S (say equal to the mass of steam admitted in the stroke) impinge against the plate *h k* with a given velocity. The result of this impact is, obviously, that the mass S loses a portion of its velocity, and consequently of its momentum, which is transferred to the air contained in the space *c*, which in its turn, communicates the chief part of this momentum to the piston *p*, the beam *b* and the suspended mass M. If the mass S be supposed to strike the plate *h k* with a velocity equal to that of the steam at its entrance into the cylinder of the Cornish engine, its percussive effect may be assumed to be the same as that of the latter, though it will in reality be greater on account of the *simultaneous* action of the whole mass, whereas the mass of steam arrives in the cylinder *gradually*. The interposition of the air *c* is essential to the perfect conformity of the two cases, for the entering steam no sooner passes the contracted orifice of the throttle-valve, where it impinges, as it were, against the steam already in the cylinder, than it expands and loses the greater part of its velocity, at the same time compressing the steam with which it mingles.

The necessity of adopting this theory (of the Percussive Action of Steam) was forced upon Mr. Parkes by his inability to discover, in the simple-elastic force of the steam employed, an amount of power adequate to accomplish the actual duty ascertained to have been performed by several of the Pumping Engines in Cornwall, the facts observed admitting of no question. This is, in our opinion, the only valid argument brought forward by the author in its favour, though he has adduced several others in corroboration, which, however, require the co-existence of the former to give them weight, and even so they are but of a negative character, amounting in substance to this: since the amount of power due to the steam's elasticity alone is less than the amount of work done, an additional quantity of power must be derived from other source; and whence can it be derived but from the instantaneous action transmitted to the piston, on effecting the sudden communication between the steam in the cylinder and that in the boiler.

Assuming the data furnished by experiment to be correct, (and we have no reason *à priori* to doubt their accuracy), the above reasoning appears to be conclusive, at least in so far as the additional power required to realize the observed dynamic effect must be sought in some property of steam distinct from its elastic force; and its Momentum, or rather Inertia, is the only property which suggests itself as capable of supplying any additional amount of power.

Admitting, therefore, the inadequacy of the simple elastic force of the steam to accomplish the work actually performed, and assuming the deficiency of power to be supplied by the Steam's Percussive Action, the next step naturally, is to examine into the causes and effects of this action.

The cause is obvious, and is almost sufficiently explained in the illustration which we have given above. A mass of dense steam passes through the throttle valve at a great velocity, the chief part of which it loses by the time it comes to act by its elastic force upon the surface of the piston. This mass of steam must, therefore, in losing its velocity, impart its momentum to some other body or bodies, through the medium of which it may afterwards be utilized in increasing the dynamic effect of the steam. The body which receives the shock of the entering steam, and transmits its momentum to the moving parts of the engine, is the steam cushion represented in the illustration by the air *c*, and the entering steam by the mass S. It is this imparting of its momentum which is called the Percussive Action of the steam.

In investigating the effects of this action, our object is to ascertain the amount of momentum transmitted thereby to the piston and other pieces of machinery connected with it, and we looked in vain to Mr. Parkes' work for assistance in this inquiry; there is, indeed, an article (page 269), headed: *Determination of the quantity of Percussive Action*, which commences with the statement that "the dynamic effect, or quantity of action, due to percussion, is discoverable, and assignable for each example; but the only method employed by the author for its determination is that of elimination, that is, by deducting from the total dynamic effect of the steam found in the quantity of work done, the amount due to its elastic force, including expansion, the remainder, which is the deficiency of power according to the ordinary theory, being attributed to the percussive action. In a note at the foot of the same page Mr. Parkes says: "It forms no part of my task to investigate the abstract question of the quantity of this species of force to be obtained from steam; my present purpose is confined to the determination of the effect attributable to it in the three engines subjected to analysis." It is a pity he did not make it part of his task to investigate, not *the abstract question of the quantity of this species of force to be obtained from steam*, but *the practical question* of the quantity which the steam would afford in the three cases under consideration. This inquiry would, doubtless, have been full of difficulties, should the result not turn out to be equal to *o*, which we much suspect would be the case if the investigation were based on the laws of percussion as laid down in the treatises on Mechanics; and if the new principle is to be established in opposition to these laws, it is necessary first to demonstrate their fallacy; but that this is not the view of the case taken by the author is evident by his merely comparing the percussive action of the steam to the shock of a solid body, without intimating in any way that the laws laid down for solid bodies do not obtain equally with regard to steam. He overlooks, however, the important consideration that the shock of the entering steam is not received immediately by the piston, but by the steam previously occupying the space above it, and likewise that the reaction is necessarily equal to the force of impact.

By reason of this latter condition the entering steam can only part with its momentum as fast as the steam in the cylinder is capable, *by its simple elastic force*, to oppose a resistance, or reaction, equal to the force of percussion. The latter is therefore always strictly measured by the elasticity of the steam in the cylinder, the dynamic effect of which thus includes that due to the Percussive Action. If, then, the Indicator diagram exhibits a faithful representation of the elastic force of the steam as it varies from the commencement to the termination of the stroke of the piston, it must necessarily furnish us with the means of determining the whole amount of dynamic effect which can be obtained therefrom. It may also be observed that the effect of the Percussion is transmitted, "by the property of fluids," to the Indicator piston as well as to the working piston, so that, even if there were a Percussive force which acted on the latter in addition to the elastic force of the steam, its influence, being felt by the former also, would be indicated in the diagram by an additional elevation of the pencil.

The above discussion convinced us, as it may also some of our readers, and perhaps Mr. Parkes himself among others, that the difference observed between the amount of power due to the elastic force of the steam and the duty actually performed by the engines subjected to analysis cannot be attributed to the Percussive Action of the steam; and, as there appears to be no other source of power to which it can be ascribed, we are compelled to conclude that the supposed difference does not exist in fact, and consequently that either the experimental data, or the calculations based upon them, are erroneous.

We have said above that we had no reason *à priori* to doubt the accuracy of the observations, and we will therefore now examine into the details of Mr. Parkes' calculations relating to the Huel Towan engine, with the view of discovering whether the discrepancy observed between the power developed by the simple elastic force of the steam and the actual work done be not attributable, either wholly

or in part, to some error in his deductions from the data furnished by observation.

Mr. Parkes says (page 261): "The absolute resistance consists of the weight which performs the return stroke, plus the value of engine and pitwork friction, and of the elasticity of the uncondensed steam." To this should be added, for each forcing pump, the weight of a column of water whose base is equal to the sectional area of the plunger and altitude to the mean height of the bottom of the plunger above the level of the water in the cistern whence it is drawn, and for each lifting pump, the weight of the whole column lifted, from the level of the water in the cistern; and we should deduct the amount of assistance, though small, given by the atmospheric pressure on the top of the piston rod.

We are not informed of the value of any of these quantities, except the last, from direct experiment, but we know that the weight which performs the return stroke is necessarily slightly in excess of that of the average column of water raised, augmented by the friction of the water and machinery, and the difference between the atmospheric pressure and that of the steam, during the return stroke, on the area of the piston rod; and the excess (which is necessary to set the engine in motion with its load of water) is counterbalanced at the end of the stroke by the cushion of steam which brings the engine to rest.

Mr. Parkes substitutes for this weight, in his calculations, the water load, which, he says, can alone be termed a positively ascertained quantity; but in computing this load he commits two errors, which, however, compensate each other. He calls the mean diameter of the pumps 14·625 inches, instead of 14·968, which renders it necessary to assume a cubic foot of water to weigh 65·47 lb., instead of 62·5 lb., in order to make the water load equal to 6866644 lb., in which he agrees with Mr. Henwood, by whom the experiment was made. It is permitted, in calculating the effective resistance on the piston, to use the total height of the column of water, since it is equal to the sum of the average heights mentioned above; so that the absolute resistance will be equal to the weight of the total column of water raised, *plus* the friction of the water in the pipes, twice the friction of the machinery, and the elasticity of the uncondensed steam, *minus* the difference between the pressure of the steam during the return stroke, and that of the uncondensed steam during the working stroke, on the area of the piston rod. The diameter of the piston being 80 inches, and that of the piston rod 7 inches, the area of the former minus that of the latter, or the effective area of the piston, is equal to 4988·08 square inches, and the resistance on the piston due to the water load is consequently 11·01 lb. per square inch. (Mr. Henwood by some mistake made it only 10·2 lb. per square inch, which he also called the whole resistance of the engines). The elasticity of the uncondensed steam is estimated at 1·25 lb. per square inch, and that of the steam in the cylinder during the return stroke appears, by Mr. Henwood's indicator diagram, to have been about 6·4 lb. The difference between these two last quantities, reduced in the ratio of the area of the piston rod to the effective area of the piston, becomes 0·04; and we find the whole resistance per square inch of the piston (assuming with Mr. Parkes that the frictions, the actual amount of which we have no means of ascertaining, cause a pressure of 5·75 lb. per square inch) equal to

$$11{\cdot}01 + 5{\cdot}75 + 1{\cdot}25 - 0{\cdot}04 = 17{\cdot}87 \text{ lb.}$$

We think, with Mr. Parkes, that this amount is by no means exaggerated, but more likely the reverse, particularly in the evaluation of the frictions, and must therefore conclude that the error, if any, must be in the calculation of the power from the indicator diagram. Now we have satisfied ourselves that the mean elasticity indicated by the diagram would not produce sufficient power, so that we have no alternative left but to prove the diagram false or to confess ourselves unable to account for the facts observed by Mr. Henwood.

If we admit the pressures to have been as shown in the diagram, and that the equilibrium valve was closed when the piston was 9 inches from the end of the return stroke, we must either suppose the unreasonably large space of 68·069 cubic feet to have existed below the piston at the bottom of its stroke, or, (if we allow thirty cubic feet,) we must assume a waste of 7·4 per cent. of the water expended. On the latter hypothesis, the volume of steam of 6·4 lb. pressure discharged from the cylinder every stroke was 352·886 cubic feet, which is the capacity of the space below the piston when the equilibrium valve is closed, and the volume remaining above the piston was $25{\cdot}979+c$, calling c the capacity of the space above the piston when at the top of its stroke, or the volume of the steam-cushion. The whole quantity of steam in the cylinder of this elasticity is therefore equal to $378{\cdot}865+c$, and its relative volume 3668. The space it occupied before the equilibrium valve was opened was $346{\cdot}393+c$, its elasticity was 7 lb. per square inch, and its relative volume 3377, so that we can find the value of c from the following proportion,

$$32{\cdot}472 : 291 :: 346{\cdot}393+c : 3377,$$

whence

$$c = 30{\cdot}438 \text{ cub. ft.}$$

The absolute volume of the steam which formed the cushion was, before compression, 56·417, and its relative volume 3668; after compression its absolute volume was 30·438, which makes its relative volume 1979, and its elastic force 12·48 lb. instead of 10·7, as shown by the diagram. Mr. Parkes gives 9·176 cubic feet as the value of c, which would evidently increase the difference between the calculated and the observed pressure of the steam-cushion.

The volume of steam of 7 lb. pressure in the cylinder just before opening the equilibrium valve is 376·831 cubic feet, and the volume occupied by the same steam when the piston had described one fourth of its stroke, and the admission valve was quite shut, was 117·036 cub. ft., so that the relative volume of the steam was then $3377 \times \frac{117{\cdot}036}{376{\cdot}831} = 1049$, and its elasticity 24·87 lb. per square inch; according to the indicator diagram it was only 20·4 lb.

We have no means of testing the correctness of the pressures marked by the indicator during the period when the admission valve was open, but the above calculation suffices to prove that the diagram is far from furnishing an exact measure of the steam's elastic force at least in the instance quoted, and that if the whole, or nearly the whole, of the water expended passed through the engine in the form of steam, it was sufficient to produce, by its simple elastic force, a dynamic effect equal to the work actually performed, particularly if the volume of the steam-cushion was only 9·176 cubic feet as stated by Mr. Parkes, and which accords with Mr. Henwood's datum of the volume of steam used per stroke.

Mr. Parkes has rendered some part of his paper rather difficult to understand by an ambiguity of expression relating to the expansion of the steam, accompanied in one place by an apparent contradiction in the facts. He says (page 264), "it is evident that the effect of a given weight of water as steam, consumed during a stroke, will be the same, whether that steam be regarded as having been all enclosed between the piston and cylinder cover, before the piston were permitted to move, when it would expand nearly uniformly from the beginning to the end of the stroke; or, whether it be considered as having been admitted during a portion of the stroke, at some pressure greater than the resistance, and then expanded through the remainder of the stroke."

What the author meant by this we cannot guess; taken literally, it is obviously false, and that it was not intended to be understood so, appears by the calculation of the effective power in the sequel. He continues:

"But, the value of expansion consists, virtually, in the quantity of action derived from the steam, after *it forms an equilibrium with the resistance*..... By tracing it, first, through the space of the cylinder, where *it would barely balance the resistance*; and secondly, through the space during which *it suffered expansion below that pressure*, a true measure of the respective and total quantities of action developed by it, expansively and unexpansively, will be obtained."

The expressions in italics imply that the expansive is separated from the unexpansive part of the stroke at the point where the pressure of the steam is equal to that of the resistance; but the numbers quoted in the next page prove that such was not the author's meaning, for he says, "when the piston of the Huel Towan engine had passed through 50·7 out of 120 inches, which was its total length of stroke, the steam's elastic force and the resistance counterpoised each other." Now we are informed that the resistance was 18·01 lb. on the square inch, and the indicator diagram shows a pressure between 13 and 14 lb. at the point mentioned; but in the diagram of the steam's action at page 294, a pressure of 18 lb. is marked at that point, and the steam and resistance are said to be in equilibrio. We are unable to account for this discrepancy.

A series of well-conducted experiments with Cornish single-acting engines would not only be very interesting with regard to the working of these engines, concerning which so much doubt is still entertained, but would doubtless throw a great deal of light on the general theory of the steam-engine, since they afford facilities for making observations which double-acting engines do not admit of.

A New Line of Atlantic Steamers.—The *St. John's N. B., Herald* informs us that the English Government is about contracting for an additional line of steamers to the North American colonies, which will give a weekly communication with England. The new line will be likely to run direct to St. John's, such being Sir William Colebrook's wish, while the present line will continue to run to Halifax. We presume the new line will be extended from St. John's to this port.—*New York Evening Post.*

BRONZE GATES.

Fig. 1.—Elevation of Gate.

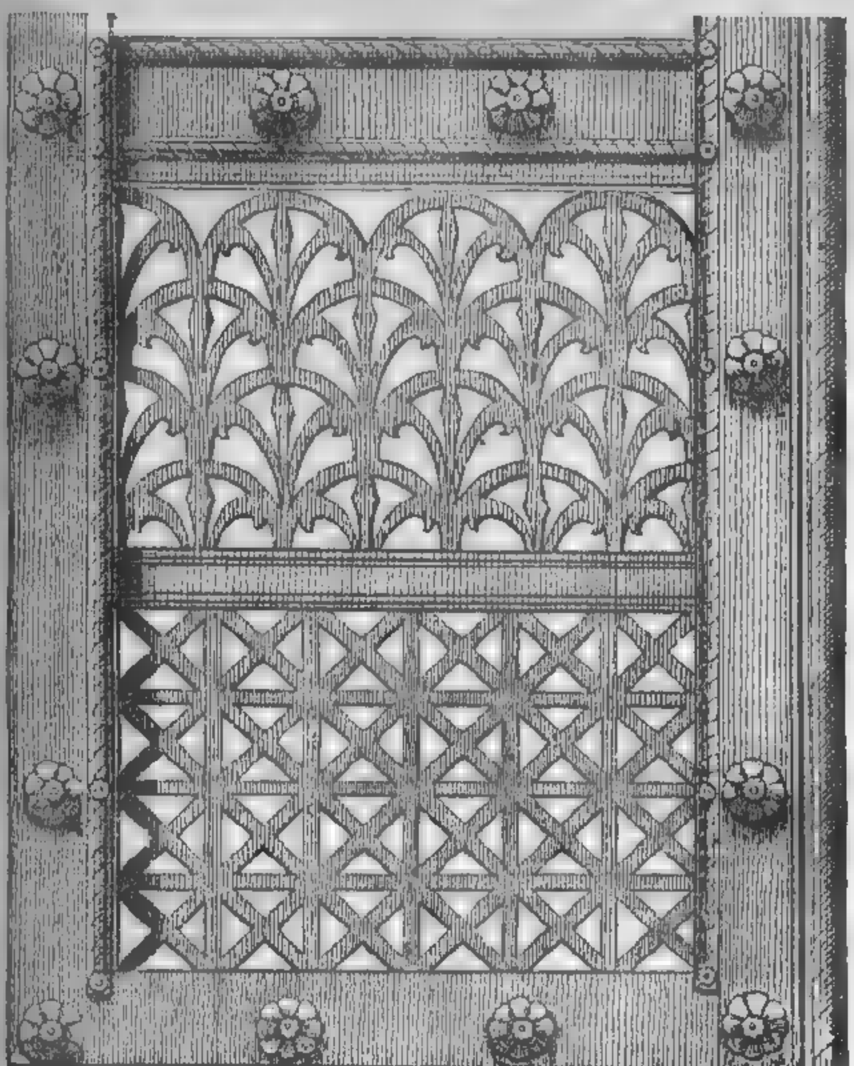


Fig. 4.—Section.

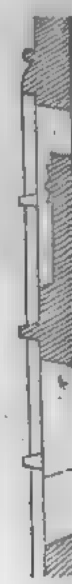


Fig. 3.—Elevation.

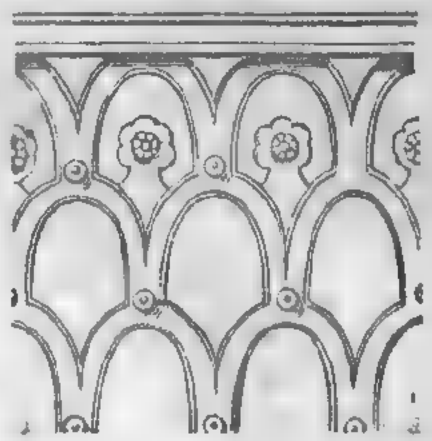
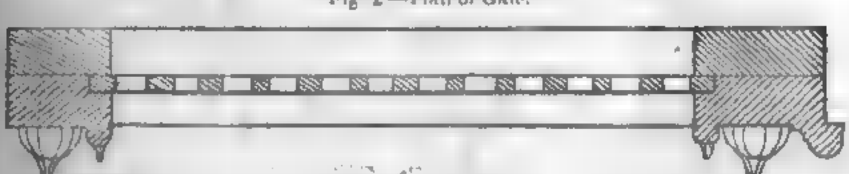


Fig. 5.

Fig. 2.—Plan of Gate.



The "*Revue Generale*" intends to give a series of designs of bronze gates selected from the best examples to be found in France, some of which we propose occasionally to give in the Journal. The annexed engravings represent the celebrated bronze gates of the Cathedral of St. Mark, at Venice.

Fig. 1 is a double panel of one of the gates; two styles and two cross rails, ornamented with projecting nailheads and torus mouldings enclose the principal panel, which is divided into two open compartments by a horizontal rail; the lower part is an exact copy of ancient cross-barred work, and the upper presents an imitation of the *imbrications* often made use of by the ancients; the hollow formed by each of the semicircles is occupied with a kind of fleur-de-lis, such as is generally depicted during the middle ages. The ensemble of this composition is original, and perfectly answers the object proposed.

A horizontal section (fig. 2) shows the arrangement of the different parts of this gate, the thickness of the panels, and the projection of the mouldings and rails which ornament it.

Fig. 3, is a fragment of another panel of the same church, which also exhibits Roman imbrications; in the upper row the artist has introduced some detached flower ornaments, which have a good effect. Fig. 4 is a vertical section of this fragment.

Numerous lion's heads, formerly gilt, are placed in the imbrications which decorate this gate, one is represented in fig. 5. The style of sculpture would serve to point out the age of the gates, were we not aware that they were cast in the 11th century, when St. Mark's was finished.

The annexed designs may be arranged in a variety of ways, so as to form some excellent examples for iron gates, railings, &c., either by repeating the same panel, or taking two panels of one design and one panel of the other, or *vice versa*. Likewise by omitting any part of the ornaments, or all, or introducing others, and the same framework may be applied either vertically or horizontally.

CANDIDUS'S NOTE-BOOK.

FASCICULUS XXIX.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. CAMPBELL'S Vitruvius Britannicus contains a design for a church, by himself,—"an original invention," as he calls it,—which is nothing more than an Ionic prostyle, pseudo-peripteral along its sides, so far tolerably Grecian as to its plan, but a mere parody of Grecian architecture, as to style. The east end has a large Venetian window, which is the only one in the building, but he says, it would give sufficient light to the whole interior; and if so, it is a pity the hint has never been taken by any one else for structures of that class, instead of cutting up and crowding their designs with a multiplicity of windows, that become so many blemishes, as is the case with St. Martin's Church. In all the various styles of pointed architecture, windows are principal and almost indispensable features, they and doorways being the chief source of decoration, and of character; whereas they are so much at variance with either the Grecian or the Roman style, if intended to be kept up with tolerably consistency, as to be hardly admissible, more especially where the general idea is affected to be borrowed from that of an ancient temple, whither it be a peristylar or merely a prostyle one. Its windows detract *very* materially from the design of St. Pancras' Church; and when it is viewed obliquely, the flank of the building produces a harsh and disagreeable contrast with the portico—which last is not disfigured, as too frequently happens with any apertures of the kind. That there is authority for windows in ancient structures, is undeniable, because those of St. Pancras are copied from the same edifice as the order itself, and the ornamental details. But then, the application of such features is altogether different from what it is in the original precedent. In the last there are only three at one end of the exterior; in the professed copy there is a range along each side, besides a series of smaller ones below, which gives an air of insignificance to the whole. Were there no other objection against them, it is no small one that they quite contradict the portico, indicating as they do not only that the interior is divided into two floors, but that the ceiling of the lower one or ground floor, is not half so high as the doors! Without entering the church, we may guess that there is in reality no such division, but that the lower windows, are merely intended to admit light beneath the galleries. The question then becomes, what occasion can there be for windows just there, provided the interior be otherwise sufficiently lighted, as it certainly might be? What occasion in fact for side windows at all—unless indeed they can be made to contribute advantageously to external effect—when they might be dispensed with altogether, and a building of the kind—a single spacious room—be lighted entirely from the ceiling, in almost any way that would best suit the particular design?—If, for instance, there is a dome, let the light proceed chiefly, if not exclusively, from that part of the ceiling plan, instead of the concave of the dome being in comparative gloom and darkness, as is the case at St. Paul's. One advantage attending the exclusion of side windows—which except in the Gothic style are more injurious than conducive to effect—would be that the walls being solid, noise from the street would be obstructed. Whether smart Sunday bonnets in the seats under the galleries would be seen to so much advantage as at present, is a different consideration—doubtless a most important one in itself. The galleries themselves are a nuisance; and never have I met with an architect who did not cordially agree with me on that point. The pew-system is not much better, though mightily in favour with

"A loyal Church, that keeps the rich and poor
Duly apart, nor blends the lord and boor.
'Tis sweet to witness *pews*, nor mean, nor scant,
For those who pay,—*free seats* for those who can't," &c.

These lines are from a clever poem which has just issued from Albemarle-street—hitherto considered the seat of High-Church orthodoxy, and conservatism!

II. In regard to the church I have just been speaking of (St. Pancras,) I cannot help thinking that the design would have been very materially improved, had the two caryatic wings, been placed at the west instead of the east end; so as to combine with the portico, and form an extended façade. A very striking composition might have been so produced, one no less distinguished by picturesque variety than by its richness. Those wings would have balanced the tower above, and given a pyramidical outline to the whole structure as viewed in front. Neither would it have been the least recommendation of such arrangement, that the wings would have served to screen the insipid side elevations. It would however have been further desirable that instead of being merely stuck on to the body of the edifice, as at present, they should be made to unite with it symmetrically, for at present the upper line of the cornice ranges with no other line, but falls about midway of the windows.

III. Caryatides or *anthropostyle* supports to an entablature, as they may very properly be described, entirely upset the *old-women* critics' fudge as to the different orders being proportioned after the human figure, their proportions being more robust than those of the "manly Doric." Whether these columnar ladies were matrons or virgins, is a point I leave to be settled by the more curious,—and indeed, I almost wonder that no one should as yet have given us some learned twaddle in regard to it;—but it is certain that they are by no means of that maypole appearance which those dames must have exhibited, who stood for models of Ionic and Corinthian columns. After all it is possible that the Greeks borrowed the idea of Caryatides from Holland, for they are most indisputably very Dutch built, and to all appearance brawny enough to perform the office put upon them, without flinching.

IV. If for no better one, it is for this last reason that I do not object to the use of Caryatides, as being disagreeable to the feelings. Thank heaven! my feelings are not quite so refined and super-refined as to be shocked at beholding ladies of stone, bearing a burden they seem quite able to support. I should as soon think of expressing my sympathy for the Cardinal Virtues which are frequently turned out of doors, and doomed to keep watch on the outside of a building in all weathers, while the Cardinal Vices, perhaps, are enjoying themselves very snugly within.—As soon should I think of being mawkishy sentimental, and compassionating some poor devil of a Neptune who is compelled to stand as a sentinel on such a ticklish situation as the top of a pediment, to be there roasted in a broiling sun. It is wonderful how vastly sentimental many people can be, provided the display of outrageously fine feelings costs them nothing! Many a one who would almost pretend to snivel at "Patience on a monument smiling at grief," would drive over a poor old apple-woman and her stall, as unconcernedly as if she were a mere stock and stone. And yet the Apple-woman is a more perfect image of patience, than all the "Patiences" ever sculptured, were there one upon every hypocritical monument that has been erected.

V. Panegyric, as Swift observes, "is all pork, with very little variety of sauce: for there is no inventing terms of art, beyond our ideas; and when our ideas are exhausted, terms of art must be so too." This last remark certainly holds good, in regard to those writers and critics who repeat what they have picked up in praise of Palladio and Jones, pretty much as a parrot would repeat a pater-noster. They would fain insist upon our believing that those worthies possessed every architectural virtue and excellence; but to dwell upon their merits, or to examine the beauties of their edifices one by one, assigning to each its due value, is more than they care to attempt,—for reasons perhaps, well known to themselves, and not difficult to be divined by those who are not arrant gulls. Very quickly indeed are their ideas of art exhausted, for after they have uttered some stale commonplace, or vapid truism they are completely aground. It may be questioned whether "the celebrated Inigo Jones" would consider Goldicutt's publication of Heriot's Hospital, particularly complimentary, since the account of it is dispatched in less than a page and a half, without any thing being said in regard to the structure itself. Yet its beauties certainly require to be carefully pointed out, for they are of a kind quite invisible to unprejudiced eyes. Not so, however, the defects, they being glaring enough. The entrance tower might be supposed to have been intended as a whimsical burlesque on modern applications of the ancient orders; and the whole is no better than an architectural hotchpotch—an unintelligible, Babel-like jargon of styles jumbled up together. Still, for aught I can tell, the Doric entrance and Corinthian patchwork above it, may be precisely that part of the design which finds most admirers. The great charm after all, I suspect, lies in the name of Inigo Jones: take away that, and few persons would be able to discern any beauty or grandeur in it whatever.

VI. In the "Magasin Pittoresque" it is said that the windmill, built by him at Chesterton in Warwickshire, does Jones no less honour than the palace of *Blenheim*"! It is a wonder the writer did not favour us with the information that Inigo Jones was the father of the equally "celebrated" Tom Jones, of whom there is a tolerably well written life by one Mr. Henry Fielding, an author not very much inferior to some of the second-rate geniusses of our own enlightened age.

HISTORY OF DECORATIVE SCULPTURE IN FRANCE.

By Albert Lenoir, Architect.

(Translated for the Civil Engineer and Architect's Journal, from the Revue Generale de l'Architecture.)

GAULISH PERIOD.

In the earliest ages men, in however rude a condition, have always been fond of decorating their dwellings, an impulse to which the Celts and the Gauls gave way, and of which we find many evidences in their monuments. On the coasts of Britany, and on the sides of Druidic monuments, we see rude sculptures of rays and spirals so combined as to produce something of a decoration. On the well known peulvan or rough obelisk of Kervéatou in Finisterre, we find the head of a bull represented in such a way as to enable us to comprehend the outline. All other monuments which preceded the civilization of Gaul by the Greeks and Romans, except those of the Druids, having perished, we are deprived of the opportunity of describing the mode of ornamentation adopted by the Aborigines.

GREEK PERIOD.

The Phoceans, as is shown by the remains preserved in the Museum of Marseilles, brought into Gaul the elements of Asiatic art, which they used with taste. In 1773 M. Grosson, an inhabitant of that city, published a quarto volume,* in which are engravings of many ancient monuments, found within the boundaries of the old colony. Notwithstanding the mediocrity of the representations, we can easily recognize on some of the tombs, decorated with bas reliefs and inscriptions, how completely they had succeeded in imparting a classic taste, the crowns of olive leaves, and wreaths of flowers and foliage boast the same elegance as on the coasts of Attica or the Peloponnesus, Caria or Ionia. On the borders of the territory of the Greek colony, in a place called Le Bas Vernègues, near the Pont Royal, on the road from Aix to Lambesc, is to be seen a temple of the Corinthian order, evidently of a Greek character, both as regards its general composition and the style of its mouldings and ornaments, as may be judged by the following engraving.

Fig. 1—Leaves of the capital of Vernègues.

The capital of a grave form, notwithstanding the richness of its details, is decorated with sharp cut leaves, like those still to be seen at Athens, and on the coasts of Asia Minor. It reminds us of the foliage used in the decoration of the capitals of Pompeia, sculptured in the Hellenic school. In the temple of Vernègues, the bases of the columns, the mouldings of the pedestal, and the proportions of the architraves have evidently been designed and executed by Greeks.

The influence of the Asiatic colony was not limited to the bounds of the Marseillese territory, but was felt throughout Gaul, and thus it is we find at Vienne in Dauphiny, and at St. Remy-en-Provence, the ancient Glanum, traces of oriental art, as readily to be recognized there as in the fragments of the Phocean metropolis.

When Gaul came under the power of the Romans the Greek spirit still survived, as we may see in the case of the two cities just mentioned. At Vienne, the capitals of the temple of Augustus and Livia, were executed on the Greek plan, as may be ascertained by the finely executed sharp leaves, and in the Museum of Vienne, formed in the cella of the temple may be recognized more than one fragment which shows the Greek chisel.†

The tomb of St. Remy, raised for a Roman personage, as the inscription, figures and bas relief show, was also of Greek workmanship, this we can trace in the fragment of a capital represented in the following engraving, and further proved by the Greek contour of the mouldings.

Fig. 2—Leaves of the capital of St. Remy.

The capitals surmount the columns, decorating the upper part of the tomb; the sculpture of them is broad and well massed.

The triumphal arch at Orange is a monument cotemporary with the first victories of the Romans in southern Gaul, in it we trace something Greek, every detail serving to remind us, in some degree, of that school. The composition of the mouldings of the entablature, and particularly those at the top of the architrave bring to mind the profiles seen in the ancient edifices of Asia Minor; a cavetto is seen surmounting a line of ova, reposing on a string of pearls, a detail completely Ionian.* The modillions, decorating the principal cornice of the arch, have a remarkable peculiarity which is met with in the octagonal monument at Athens called the Tower of the Winds, and as we shall hereafter see reproduced in the Maison Carrée at Nimes, an edifice of a later date than that on which we are now treating. These modillions are sculptured in an inverse way from those which decorate all the ancient entablatures, the larger part, instead of resting against the cornice so as to form a console, is on the contrary near the outer edge of the corona, a very rational arrangement by the bye if we consider this part of the decoration as being derived from a wood building, and as the expression of the pendent extremities of the rafters, supporting the tiles. The resemblance between this entablature at Orange, and the Athenian edifice, which as it is described by Vitruvius,† must be of ancient date, comes in confirmation of the influence exercised by Greece on architecture and its details in southern Gaul. A specimen of the Greek palmetto is to be found in the midst of the foliage of the upper ogee of the impost of the Arch at Orange. The coffres, decorating the arches are executed with more delicacy than in any Italian monuments, particularly in the double arches, where we observe a happy arrangement which adds to the finish of the execution. In general, the Roman monuments of southern France show in their ornamentation a lightness of touch which may be attributed to the Greek school as introduced by the Phocean colony.

We have already shown what Hellenic elements are observable in the tomb of St. Remy; the same we have to notice in the triumphal arch of that town, particularly in the double arches decorated with arabesques. The archivolts of this monument, as well as those of the triumphal arch of Orange, are decorated with foliage and fruits, taken from the produce of the country, an interesting ornament as it makes us acquainted with the state of culture at that date.‡

ROMAN PERIOD.

Out of Provence we perceive a considerable change in the style of ancient architecture, approaching to the Roman forms, of which Nimes, one of the richest cities of Europe in antiquities, affords many examples, having been for a long time opulent enough to construct fine buildings. Augustus gave walls to Nimes, as is attested by an inscription on the gate, still bearing his name. The Corinthian capitals of the pilasters of this gate are executed with breadth, and remind us of the style at that period adopted at Rome. To the same emperor is attributed a portico which decorated the fountain of the Baths, the fragments of which are preserved on the site of the Temple of Diana. In the Maison Carrée are two of the finest bases ever sculptured by

* Recueil des Antiquités et Monumens Marseillais, 1 vol. 4to., Marseille, 1773.

† The reader may consult *Antiquites de Vienne*, 1 vol. in folio, by M. Reg. Director of the Museum of Vienne.

* See the works of M. Choiseul Gouffier and of the Dilettanti Society of London.

† Vitruvius, book 1, chapter 6.

‡ See the introductory plates to the History of France, by Jorand, Jouffray and E. Brecon.

the ancients, also parts of the fountain.* At the temple of Diana are to be seen many fragments of richly ornamented double mouldings, which decorated the lower part of the great pedestal or stylobate in the centre of the Baths. They are beautifully executed. Neither must we omit the long marble frieze of the stylobate of the fountain preserved in the Maison Carrée.

The temple of Nimes, known by the vulgar name of the Maison Carrée, and built in honour of the grandsons of Augustus, was executed by skilful artists; the capitals, in the Roman manner are broadly modelled, but we can see here, as well as on the frieze, abundant proofs of a difference in the skill of the several workmen employed. The modillions of this temple, as we have already mentioned, exhibit the same peculiarity as those on the Triumphal Arch at Orange, but being deeper cut, they are evidently imitations. The great gallery or colonnade around the temple, forming the sacred boundary, shows the same style of sculpture as the temple itself, but with less luxuriancy in the details: the frieze was formed of garlands, fruits and flowers, bound with floating ribands.

Antoninus, who was a native of Nimes, adorned that city with many important buildings. To him are attributed a temple and a basilica dedicated to Plautina; and the fragments of sculpture collected in the Museum, apparently belonging to this golden age of art, fully bear out their claims. Among these may be remarked the eagles supporting the olive garlands; and a frieze composed of ox sculls, supporting garlands of fruit.

Vienne, the rich Museum of which is formed in the temple of Augustus and Livia, possesses more than one fragment of the best ages of Roman art.† Here are to be seen the cornice, frieze and architrave of a beautiful entablature, on the frieze of which is particularly to be remarked the rosette which serves to unite the bends of the foliage. The cornice is less remarkable, showing as it does in its modillions evident symptoms of the decline of the arts, first, because their form is that of a console en talon, little in harmony with the richness of the other members; second, because these modillions are all decorated differently, which is contrary to the strict rules of the best periods of art. It is singular that among all the remains of ancient art those of France alone should be found to present these departures from the general rule, an exception which we shall have occasion to remark both during the history of the Roman period, and of the middle ages, in which this variety of form became the parent of riches to a new style. In the Museum is also to be seen a beautiful piece of monumental sculpture, forming a frieze, and consisting principally of an eagle attacking a serpent. It seems to belong to the time of Septimus Severus.

Arles, a city of little importance before the time of Constantine, rapidly increased under the reign of that prince, and became to a certain extent, the Gallic Rome. Extensive buildings, still in existence, serve to show its splendour, but art was no longer what it was under the Antonines, the theatre, capitol, amphitheatre, and great cemetery or elyseum, show by the bad taste of their details, and the transposition of the principal members of the styles, how complete was the decadence. The capitol, of which a part is still to be seen in the Men's Square, consists of a ruin composed of two columns, crowned with an entablature and the fragment of a pediment; the ornamental sculpture is neglected, the frieze being composed of scrolls without character, while in the capitals, the bad proportions of the leaves indicate the period of ignorance at which the monument was erected. The theatre exhibits greater signs of decadence than even the capitol, the entablature of the lower story presenting the greatest anomalies, the sculptors have placed a frieze decorated with triglyphs and rosettes immediately above the capitals, where the architrave ought to be; then come a frieze in bad taste, and a badly proportioned cornice. In the Museum at Arles is preserved part of a marble entablature, which appears also to belong to the time of Constantine; the modillions varying every two and two in their decoration, which we have already pointed out as contrary to the principles of classic antiquity.

The walls of the city of Sens, of which the destruction, going on even now, presents numerous details of ancient architecture, placed by the Romans themselves on hasty foundations made in the time of the Emperor Julian, have afforded several cases analogous to those we have mentioned under the head of Arles.

The city of Autun, celebrated in Gaulish history and the capital of a province, has preserved some remarkable monuments. Those in the best condition are two gates attributed to Constantine, who was a great patron of the town. These two military constructions are in good style, both as regards the architecture and the ornamental sculpture, notwithstanding the well known general decadence of art which prevailed under the first Christian emperor. In the same city an ancient entablature of the Gallo-Roman epoch, which affords an example unique in France, of modillions sculptured on the angle of the corona. The ornamental details of this fragment show one of the last periods of Roman art in Gaul; we can however recognize the fertile imagination of the native artists, in the variety of *motives* in the sculpture, which change the form and character of each modillion.

A triumphal arch of large proportions is formed in the walls of the city of Rheims, and is now known as the Gate of Mars. The construction has been attributed to Cesar by some modern writers, although there is nothing to give any foundation to this notion. An examination of the sculptural details of this edifice is enough to prevent its being assigned to any period anterior to the Lower Empire, and perhaps it ought rightly to be placed in the time of the emperor Julian, who fought often enough in the East of Gaul to obtain triumphal honours in a provincial city. In this monument the sculpture is of most uncommon barbarism, the foliage being scarcely of a recognizable form; the capitals out of proportion surmount heavy and badly chiselled columns, and the mouldings of disagreeable figure are made heavier by ornaments of which the model is a large hole in the midst of a shapeless leaf.

* Antiquités de Nimes, by Clerisseau.
† Antiquités de Vienne, by Reg.

HISTORICAL SKETCH ON THE USE OF BRONZE IN WORKS OF ART.

By Cesar Daly, Architect.

(Translated for the Civil Engineer and Architect's Journal, from the Revue Generale de l'Architecture.)

(Continued from page 219.)

The exertions of the Italian artists excited general emulation throughout Europe; and in a very short time every country used bronze for the decoration of its public edifices, and to transmit to posterity the deeds of its kings and great captains. Italy erected statues to the Medici and the Farnese, Spain to Philip III, Russia to Peter the Great, Sweden to Gustavus Adolphus, and England to Charles 1st. Much might be said with regard to the progress of this art, but we consider ourselves obliged on account of the extent of the subject to limit it to the history of bronze in France.

It was under Louis 14th, that this art made rapid progress through the enlightened endeavours of the two brothers Keller, whose principal master pieces are yet to be seen adorning the royal palaces of Versailles and the Tuileries. In 1699, Balthazar Keller cast in one piece the equestrian statue of Louis 14th, modeled by Girardon. This colossal mass was more than seven yards high, and yet weighed only 26,072 kil. (57,50 lb.) It seemed however as if the art of founding had only attained this state of perfection soon to fall into decadence; the equestrian statue of Louis 15th, cast by Gor in one piece, from the model of Bouchardon, and afterwards raised on the Place de la Concorde, was only 5·40 m. (17 ft. 9 in.) in height, while its weight was 29,370 kil. (64,775 lb.) During the revolutionary crisis, the only bronze work was limited to cannon; but under the Empire, bronze was again appealed to, to take its place among the other arts in representing the military triumphs of the French. Unfortunately the art had been too long neglected to allow of success, and some of the first essays were not prosperous, the statue of Desaix was a complete failure, and the Column of the Place Vendôme is far from being a master-piece of founding.

According to M. Payen, to whom we are indebted for the following details, the execution of the Desaix statue was put up to contract, and it was undertaken for 100,000f. (£4,000), a price in which the bronze was not included. The contractor gave up his bargain to a bell-founder, and he knowing nothing of the fashioning of such great works, and calculating upon the basis of his ordinary limited operations, engaged to do it for 20,000f. (£800); but in order to economize as much as possible, he required that the sculptor should be forbidden from superintending the moulding. The most difficult hollows were filled up, in order to avoid the trouble they would occasion; an attempt was made to mould in sand with frames, furnaces were erected, and an ill-constructed scaffolding, and after many useless arrangements and expenses, the bronze was let out, and having burst the moulds, ran about. Thus the operation completely failed, a good deal of the bronze was lost, and it was necessary to begin again. The founder then tried to cast the monument in pieces, but not arranging his moulds well, nor securing a uniform mixture of the metal, the pieces produced were dissimilar. He managed however to fit them together, but all the proportions of the figure were altered, and as these defects could not be remedied by the chisel, a most wretched monument was produced.

When the Column in the Place Vendôme was erected, the same faults were repeated; a bargain was made with an ironfounder, who had never been engaged in bronze work, he however had the temerity to undertake the moulding and finishing at one franc per kilo. (9*d.* per 2 lb.) The government on the other side undertook to deliver to him in guns, taken from the Russians and Austrians during the campaign of 1805, the quantity of bronze necessary for the completion of this enormous monument. The founder used a furnace he had for casting iron, but not being aware of the phenomena of bronze casting, and urged by his vanity to attempt in the first instance the casting of several of the great pieces of the base of the column, he encountered several defeats. Each time he necessarily altered the alloy by oxidizing the tin, lead and zinc, which metals so oxidized passed into the scoriæ or were carried off by the current of warm air. He did not perceive this cause of continual loss, and continued to produce the bas reliefs; but it may be readily conceived that they contained more copper than the bronze of the guns. When the founder had got two thirds through the column, he found out that he had got no more metal, and being, according to contract, responsible for the metal delivered to him, he was at once ruined. In this lamentable situation he tried to melt up the white metal obtained from the reduction of the scoriæ, and a large quantity of refuse metal which he had bought up at a low price. The bas reliefs which he obtained from the mixture of all these materials were marked with blotches and lead spots, their colour from a dirty grey became quite black; the authorities refused to receive work so defective, and put his foundry under sequestration. He succeeded, after much petitioning, in obtaining a committee to examine his accounts, which was composed of two chemists, two architects, two mechanical engineers, and two founders, with an auditor of the Council of State for the chairman. The weight of each piece delivered by the founder was known; specimens were taken from them, and the proportional parts weighed, from which was made an ingot representing the mean composition of the whole column. It was then found by analysis that it contained:

Copper	89·440
Tin	7·200
Lead	3·313
Silver, zinc, iron	0·047
	100

The committee then took specimens of bronze from the guns remaining in the government stores, and an ingot was formed to represent as nearly as possible the mean composition. The analysis of this ingot gave the following proportions:

Copper	89·360
Tin	10·040
Lead	0·102
Silver, zinc, iron, loss	0·498
	100

It was further known, that the law in France had fixed the composition of gun metal at 90 parts of copper and 10 of tin per cwt., but that this law was never well executed, and during the revolution scarcely attended to at all; it was also known that these foreign guns were of a more complicated and baser alloy than the French. Taking all these circumstances into consideration the committee were of opinion that the founder had produced an alloy, if not superior, at least equal, to that which had been given to him; and that they considered that he could not be charged with fraud in his contract. The chemical operations further explained the whole proceeding; by making separate analyses of the specimens of the great bas reliefs, the shaft, and the capital, it was found that the first had only 0·06 alloy per quintal; the second, particularly towards the upper part, and the third contained as much as 0·21. It was therefore evident that the founder not knowing how to manage bronze, had refined his alloy by several times remelting, and consequently diminished the total weight, and that to make up for this loss, he was obliged to put into the last castings the white metal extracted from the scoriæ. Thus he had given bronze of too good alloy in the beginning, which had obliged him at last to make the alloy too low. The moulding of the several bas reliefs was so badly executed, that the chaser employed to go over them, removed by chiseling or filing, a weight of bronze equal to 70,000 kils. (7 tons), which were given to him, besides a sum of 300,000f. (£12,000) paid down.

It was certainly hard to pay so dearly for experience, but fortunately it was profitable; not however that all the subsequent bronze works in France have been more successful, for the founders had to submit to several severe checks, and were obliged to study the processes, and proportions necessary to form a good alloy. Thus when in 1817 Lemot was employed to cast the equestrian statue of Henry 4th, now on the Pont Neuf, he at least took the precaution to take specimens from three bronze statues of Keller at Versailles, which were the best, with regard to casting, green colour, and the grain. The following is the result of his analysis.

	No. 1.	2.	3.	Mean.
Copper	91·3	91·68	91·22	91·4
Tin	1·	2·32	1·78	1·7
Zinc	6·09	4·93	5·57	5·53
Lead	1·61	1·07	1·43	1·37
	100·	100·	100·	100·

Lemot thought that he had gained experience enough from these analyses, but he did not escape from serious difficulties during the casting. Wishing to make use of the furnace, which had been built for casting the equestrian statue of Louis 15th, formerly in the Place de la Concorde, but the furnace not having sufficient draught for the fusion of Keller's alloy, in which there was more copper than in that of the statue of Louis 15th, he was obliged after several trials to make great changes, and still the casting did not perfectly succeed. The body of the king had several hollows in it, and the belly of the horse failed, a hole so large having been formed that it was obliged to be filled up; further 14,000 kilo. (14 tons) of oxidized rubbish was sold off.

Casting in bronze, although presenting only slight difficulties in the manufacture of objects of small dimensions, has always required greater responsibility when it is required to form considerable masses, perfectly homogeneous. The component metals are deficient in energetic affinity for each other, when in fusion tend to separate in the order of their densities, and, when the less fusible begin to solidify, the others in a liquid state, rise up towards the top, where the easy oxidation of a component part of the alloy always causes the risk of refining the metal. Besides these great obstacles, others are encountered in calculating the several component parts of the bronze, where it is wished to obtain precisely the required quantity of metal for the object to be cast, also in the preparation of the model, the construction of the furnace, and the disposition of the moulds. These and other difficulties explain how many abortive attempts sometimes preceded in former days the casting of a large work in bronze. They point out why Falconnet was 15 years casting the equestrian statue of Peter the Great, which figures on an immense monolithic pedestal at St. Petersburg; why the Kellers were 9 years casting the statue of Louis 14th; why Bouchardon and his successor Pigalle took 8 years for that of Louis 15th, on the Place de la Concorde; why the statue of Desaix, and we may almost say the Column of the Place Vendôme, failed, and why the great equestrian statues we have mentioned did not come perfect out of their moulds. The statue of Peter the Great was obliged to be begun again from the knees of the Czar and the breast of the horse, to the top of the statue. Bouchardon had much trouble in restoring the delicate forms of the horse in his beautiful equestrian statue of Louis 15th, which were badly produced in the lower part, and we have related the difficulties encountered by Lemot and Piggiani in casting the statue of Henry the 4th, difficulties which lasted four years. We cannot better finish this essay than by mentioning those which have just been surmounted in casting the various parts of the July Column, and for the better effecting this we shall compare it with the Column of the Place Vendôme, which is the only one having any analogy to it. The Vendôme Column is only coated with bronze, and the largest pieces are only five yards in extent, while each of its tambours is composed of six pieces, and the whole cost of the column in specie and metal provided by the state was 2 millions (£80,000). The July column on the other hand is entirely of bronze, and each tambour is in one piece, the base of the column extends about 16 yards, and the capital at the most extended place has the enormous dimension of 26 metres, 85 feet. This column however only cost 1,172,000 francs (£46,880).

Inequalities in the thickness of the parts constitute one of the great difficulties of casting, because the thin parts cooling rapidly, and the thick parts slowly, the shrinking of the former taking place sooner than that of the latter is apt to split the metal. It may be also conceived that the shrinking of a large object is so much more than that of a small one, as its dimensions are greater, and the necessity for taking this into consideration causes a fresh difficulty in the construction of the mould, which must be calculated so as to provide for the contingency. It is easy in the same way to conceive that the least motion of the mould, during the operation, will cause the required thickness to be exceeded. These considerations will explain the difficulties which had to be surmounted in casting the several parts of the Column of July, and as to the statue we cannot do better than re-

publish an extract from the report of M. Hericarb de Thury, made to the *Société d'Encouragement*, on the improvements introduced by M. Soyez in the moulding of bronze sculptures.

"This statue 4·25 m. (14 feet) in height, supported on the toe, and bending forward, presented great difficulties in the moulding, and still greater in the casting, as the solidity of the statue depended on the extreme lightness of the upper parts, and the strength of the leg on which it is supported. Had the old methods been resorted to, the figure would most probably have failed, or have been tried in several pieces; because the upper part being very thin would cool down immediately, while the lower part cooling more slowly, would have contracted on itself, leaving at the ancles an opening of about 25 millimetres (an inch), the metal contracting from 12 to 14 millimetres per metre (½ an inch) and the statue would undoubtedly have been lost. To obviate these difficulties, M. Soyez determined upon casting it head downwards, by which he diminished the danger, I say diminished, for in this posture, the mould must have yielded, or the leg broken above the ancle. To provide for this, M. Soyez placed on each side of the foot a branch of copper 0·6 met. (26 in.) broad, finishing in a strong head, so as to force the foot to contract on the knee. Further these branches were so managed as to be rather thinner than the leg. Full success crowned the trial of this bold and ingenious innovation, the casting of this admirable statue succeeded in every detail, being perhaps the first time that a figure of this importance was cast without any defect. The thickness of the statue is from 4 to 5 millimetres (a sixth to a fifth of an inch) in the upper part, except the wings, which are only 2 millimetres. The supporting leg is 55 millimetres (2¼ inches) thick, beginning from the ancle, and progressively diminishes in thickness up to the thigh."

The monument of July undoubtedly marks a new era in the history of the art of bronze casting, and places France in the first rank in its pursuit, and in order to do justice to M. Soyez, we must mention some of the improvements effected by him. This artist has got rid of the use of iron as a means of consolidating isolated parts of figures, and particularly in supporting members; he casts these parts full by turning the figure upside down, which is an important innovation. He gets over the resistance of the sand of the mould on the contraction of the metal, not only by the weight of the mould, but by the progressive tenacity of the bronze while cooling. This tenacity, which may be considered as proportional to the area of the section of the part so cast, is increased at pleasure by accessary parts placed in the mould according as they are wanted. It is thus that the Genius of Liberty was cast, having as it were a second shapeless leg placed parallel to that which supports the figure, and intended to become at the period of contraction, auxiliary to the statuary leg to which it was united by the two extremities. Thus also was cast the bent back leg of the horse of Charles Emmanuel of Savoy. In order to prevent this leg from breaking in the ham when cooling, the foot was united to the thigh by a strong tenon, which was afterwards chiselled away.

ENGINEERING WORKS OF THE ANCIENTS, No. 7.

WORKS OF HERCULES.

Besides the performance of the Egyptian Hercules already mentioned, Diodorus Siculus, Book 4th, gives an account of several works of the Greek Hercules. Not to speak of the operations attributed to him at the Straits of Gibraltar, there were two hydraulic works in Greece said to have been executed by him. The large champain country about Tempe being all over a stagnant lake, he cut trenches through the lower grounds, and through these trenches drained all the water out of the lake, by which means were reclaimed all the pleasant fields of Thessaly as far as the River Peneus. In Beotia he did quite the contrary, for to punish the Minyæ it is related that he caused a river to overflow the whole country, and turn it into a standing pool. In his passage of the Alps from Gaul, an expedition in which he was the predecessor of Hannibal and Napoleon, he levelled and opened the rough and difficult ways to make way for his army and carriages. In Italy Hercules performed some remarkable works about the Lake Avernus, for whereas the lake extended as far as the sea, Hercules is said by casting up earth, to have stopped up its current, and to have made the way near the sea, called the Herculean way.—In Sicily to express his good wishes for the inhabitants, he caused a pond or tank to be sunk near the city of the Agrineans, four furlongs in compass, which he called after his own name.—In Greece Hercules had the further merit of having diverted the River Achelous into another channel which he had dug for it. This irrigated a considerable part of the country, and was done to please the Calydonians. It gave rise to the poetical fable that Hercules fought with Achelous transformed into the shape of a bull, and in the conflict cut off one of his horns and gave it to the Etolians. This they call Amalthea's horn, in which the poets feign that there grows all manner of summer fruit, as grapes, apples, and such like, not the only time by the bye that engineers have filled the horn of plenty.

DEDALUS—ENGINEERING FESTIVALS.

Diodorus gives a long account of Dedalus, from which we have made the following extracts. Dedalus was an Athenian of the family of the Erechthidæ, being the son of Hymetion, son of Eupalamus, son of Erechtheus, King of Athens. He was extraordinarily ingenious, and very studious in the art of architecture, an excellent statuary and engraver upon stone, and improved those arts with many notable inventions. Dedalus was obliged to flee to Crete for the murder of his nephew Talus, who was killed by him out of envy. To Dedalus is attributed the invention of sails for ships. After leaving Crete he staid with Cocalus and the Sicilians, in whose country Diodorus, a native, says that works of his were to be seen in that day.

While on the subject of Dedalus we must not omit what the Biographie Universelle says on the subject of festivals established in his honour. When the Plateans returned to their native city, 311 B.C., after an exile of sixty years, they instituted an annual festival called Dedalia, which every sixtieth year was celebrated with extraordinary magnificence. All the trees cut down were made into statues called Dædala. The name of Dedalia was also given to a Theban fete in honour of the reconciliation effected between Jupiter and Juno by Cithero.

TALUS.

Talus is sometimes called Atalus, Calus, and Acalus; he was the nephew of Dedalus, as before mentioned, and murdered by him. Being the son of Dedalus's sister, and but a young boy, he was bred up with his uncle to learn his trade. Talus for ingenuity exceeded his uncle, and invented the potter's wheel; he got likewise a serpent's jaw bone, and with it sawed a little piece of wood asunder, then in imitation of the tooth in the jaw, he made the like in iron, and so he found out an instrument for sawing the greatest pieces of timber. He invented likewise the turner's lathe and many other tools.

PROMETHEUS—CRETAN HERCULES—VESTA—MINERVA—VULCAN.

Prometheus is according to some the first who stole fire from the gods, and bestowed it upon men (Book 5th), but the truth is he found out the way how to strike fire out of flint or stone. The Idæi Dactyli are also said to have found out the use of fire. They discovered the nature of iron and brass to the inhabitants of the Antisapterians, near the mountain Berecynthus, and taught the manner of working it, and because they were the first discoverers of many things of great use and advantage to mankind, they were adored and worshipped as gods. One of them they say was called Hercules, a person of great renown. After them were nine Curetes who invented swords and helmets.—Vesta invented the building of houses, and upon this account almost every body sets up her statue in their houses, and adores her with divine honours.—Minerva was the introducer of architecture, and also according to our chronicler of the use of garments, so that architecture and tailoring according to him boast one common parent. Vulcan they say found out the working of iron, brass, silver and gold, and all other metals that require forging by fire; and the general use of fire in all other cases was found out by him.

XERXES—AGRIGENTUM—PHEAX—THEMISTOCLES—DIVERSION OF THE NILE.

The Eleventh Book of Diodorus, is on Greek history, he mentions Xerxes throwing a bridge over the Hellespont, and cutting a canal through Mount Athos.

The Agrigentines in Sicily having acquired great spoil by the defeat of the Carthaginians, took the greater part of the prisoners into the public service, and employed them in cutting and hewing stone. They not only set them to build the largest of the temples, but made water courses and sewers underground, so great and wide, that though the work itself was contemptible, yet when done and seen was worthy of admiration. The overseer and master of the work was one Pheax, an excellent artificer, from whom these conduits were called Pheaces. The Agrigentines likewise formed a tank for fish, at great cost and expense, seven furlongs in compass, and twenty cubits deep. This by neglect of succeeding ages, filled up with mud, and at last through length of time turned wholly into dry ground; but the soil being very fat and rich, it was planted, and yielded the city a large revenue.

Themistocles has the merit of projecting and carrying into effect the construction of a haven at the Pyræus, by which the naval power of Athens was greatly increased. The account of his negociations with

the assembly of the people is of much interest in an historical sense, but not immediately relating to the end we have in view, we are compelled to omit it.

In the 21st chapter is mentioned the diversion of the Nile during the war between the Persians and Egyptians.

BLOCKING UP OF THE EURIPUS.

In his 13th Book our historian describes the measures taken by the inhabitants of Eubœa on their revolt from the Athenians. This island being separated from the continent only by the narrow strait of the Euripus, they solicited the Beotians to assist them in stopping it up, in order that they might receive assistance against any attacks from the Athenians who were masters of the sea. To this the Beotians agreed, and all the cities set upon the work, and every one strove with diligence to perfect it, all the citizens, foreigners and strangers being set to work. The mole began at Chalcis in Eubœa on one side, and at Aulis in Beotia on the other, that being the narrowest part. In these straits the sea was very boisterous and rough, but after this work much more unquiet and raging, the passage being made so very straight and narrow, that only one ship could pass through. There were forts built on both sides upon the extremities of the moles, and wooden bridges made over the currents for communication.

CARTHAGINIAN ENGINEERING.

Our author gives an account of several sieges by the Carthaginians in Sicily, who appear from his account to have been as skilful as the Greeks in military warfare. At the siege of Himera in Sicily, Hannibal the elder (Book 13th), undermined the walls, supporting them with great pieces of timber, which being set a-fire, a great part of the walls suddenly fell down.

In the 20th Book, in the account of the expedition of Agathocles into Africa, there is a description which mentions, the country as well irrigated and supplied with canals and sluices.

MACEDONIAN GOLD MINES.

Philip, King of Macedon, (Book 16th), having taken Crenidas, and called it Philippi, so improved the gold mines in those parts, which before were but inconsiderable and obscure, that by building of houses for the works he advanced them to bring in a yearly revenue of above a thousand talents.

ALEXANDER THE GREAT.

The siege of Tyre by Alexander the Great, recounted in the 16th Book, required the execution of works on a very great scale. Alexander demolished Old Tyre, as it was then called, and with the stones carried by many thousands of men, raised a mole two hundred feet in breadth across the sea, which by the help of the inhabitants of the neighbouring cities, who were impressed for the purpose, was speedily carried out a considerable way. This mole was afterwards injured by a violent storm, when Alexander caused it to be repaired with trees laden with earth, and so again brought it near the city. By this and many other operations he was able to take the city, after a gallant defence, in which the inhabitants displayed much ability.

In the memorandum books of Alexander examined after his death, (Book 18th), were found heads of six colossal plans, among which were the following,—that a plain and easy road should be made straight along the sea coast of Africa to the Pillars of Hercules, that six magnificent temples should be built, and that arsenals and ports should be made in places convenient for the great navy he contemplated. These things, although highly approved by the Macedonians, yet because they seemed things beyond all measure impracticable, were desired to be laid aside.

INUNDATIONS.

During the Seleucian war, (Book 19th), the Macedonians under Eumenes encamped on the banks of the Tigris, about three hundred furlongs from Babylon, Seleucus occupying the river with a flotilla of small vessels. The Seleucians, having sailed to an old water course, cut down the banks at a part where it had been filled up from length of time, upon this the Macedonian camp was surrounded with water, and all the tract of ground overflowed, so that the army was in great danger of being utterly lost. At last removing a great part of his army in flat bottom boats, he caused all the Macedonians to repass the river, and then for the purpose of recovering his carriages and baggage, by the direction of one of the native inhabitants, he set about cleansing such another like place, by which the water might be easily diverted, and the ground all round about drained dry. When Seleucus perceived this he granted a truce, and the works were suspended.

In the same book is the account of the natural inundation, by which the city of Rhodes was so much injured. Rhodes being built in the form of a theatre, and the rain very heavy, the water ran for the most part into one place, and the lower parts of the city were presently filled with water, for the winter being looked upon as over, no care had been taken to cleanse the channels and sewers, and the pipes likewise in the walls were choked up, so that the water stood several feet deep, until part of the city wall breaking down, the pressure was suddenly relieved.

PILEWORK.

In a mention of the Cimmerian Bosphorus in Book 20th, it is related that the king's palace was surrounded with the river Thasis, and that there was a road to it through the fens, guarded with forts and towers of timber, raised upon pillars over the water.

DEMETRIUS POLIORCETES.

We find in the 20th Book a long account of the siege of Rhodes by the celebrated Demetrius, who among other works made extensive mines under the city walls, which being told to the Rhodians, by a deserter, the Rhodians made a deep trench along the walls, which was now ready to be tumbled down, and forthwith fell to countermining, and at length met the enemy under ground, and so prevented the mine from proceeding any further.

MR. MUSHET'S PAPERS ON IRON AND STEEL.—No. 3.

Sir,—The opinions adopted by Drs. Ure and Karsten respecting the quantity of carbon in iron, namely, assigning to white cast iron a larger proportion than to gray, and taking the manifestation of the graphite fracture in the latter as a certain sign that the quantity of carbon in the metal is on the decrease, appear to me so much at variance with, and subversive of, all that practical men have understood and believed upon this subject, that it is my intention, with your permission, to make a few remarks upon the matter, in order to ascertain, by an examination of facts, how far they are borne out by the appearances which we every day see exhibited on the scale of manufacture, and in the manipulation of the metallurgical department of the laboratory.

I hope your readers will not consider I have travelled out of my way to make any gratuitous observations on Dr. Ure's most elaborate work further than the necessity of the case required, seeing his views of the subject are at direct variance with my table of the proportions of charcoal used in the fusion, and in forming the various qualities of iron and steel so frequently referred to in these letters.

As a prelude to the subject, and with a view to enable your readers to arrive at a more clear understanding of the points at issue, I shall define and class the distinct characteristics which cast iron assumes. Nothing can be more marked in the page of metallurgy than those divisions in the progressive stages of this metal:

1st. Steel-grained cast-iron, or crude steel.
2nd. White cast iron.
3rd. Gray cast iron.

In the absence of chemical analyses, but grounded upon numerous direct and comparative experiments, I have considered steel-grained cast iron to contain from 1 to 1½ per cent., the white cast iron from 1½ to 2½ per cent., and gray cast iron from 2½ to 4, or, when richly carburetted, to 4½ or 5 per cent.

Steel-grained cast iron is rarely to be met with at the blast furnaces in this country: decided traces of it are occasionally to be found in the commencement of a blast, particularly should the furnace be started with too heavy a charge; a high temperature being required to maintain its fluidity, it either sets on the bottom of the furnace, to be cleared off afterwards by an alloy of gray iron, or it escapes with the white iron when the furnace is tapped. At this juncture, which, when steel-grained iron is produced, is always one of difficulty in the affairs of the furnace, should the iron which has been obtained be examined, it will be found possessed of a white fracture, frequently mixed with a portion of the steel-grained iron.

Calcareous ores, however, afford the steel-grained cast iron more as a natural product; the supposed alloy of the metal of lime with the iron produced from those ores, renders the white cast iron more lively and fluid than the gray, and becomes in some measure a substitute for carbon in maintaining a considerable degree of fluidity, when the metal is at any time passing into the steel-grained quality, so as it may be run out of the furnace in quantity, and with a comparatively clean cinder.

Castings made of such iron possess a degree of strength quite unknown in the general operations of the foundry; they will beat up like soft steel, and acquire by hammering a permanent flexure like malleable iron; but, as far as my information and experience go, all attempts hitherto to remelt it have failed.

Rare as this peculiar state of the metal may appear to the iron

maker of this country, yet the whole of his metallic produce, in passing through the furnace, must have, in the first instance, been subjected to this process of steelification, before it absorbed enough of carbon to constitute it white cast iron. It may, however, be produced at any time artificially, by exposing white cast iron, particularly of that quality that merges on the steel-grained, in an open or covered furnace for some time to the action of a red heat, the time of exposure to be commensurate to the thickness of the iron employed. This operation has the effect of discharging the white or lamellar fracture, and substituting in its place one of a grayish colour, very dense, and minutely steel-grained, the process itself being one of decarbonization, and which, from its colour and softness under the file, ought not to be taken, as it sometimes is, for a manifestation of an increased quantity of carbon in the iron.

2ndly, as white cast iron occupies a position between steel-grained and graphite or gray iron, and is frequently found merging in both, it of course possesses a variety of quality and character greater than either of the other two, so as to render the details of experiments made with this variety of the metal subject to greater uncertainty than with the graphite or steel-grained.

Dr. Ure has assigned no definite quantity of carbon to the steel-grained iron, but that, in his estimation, it possesses a notable proportion, may be gathered from what follows: he assigns to white cast iron a maximum dose of 5¼ per cent., and further states that with a proportion of 4⅜ per cent. it still retains its white or lamellar fracture. So that in the absence of more correct data, it may be inferred that when the change to steel-grained iron has taken place, the iron has lost 1 per cent. and still retains about 3⅜ per cent. of carbon, so that as it regards carbon, the iron is in the same situation with good foundry iron, but observe the difference when this theory is tested by practice—the foundry iron will melt in an air furnace, and come out as fluid as water, while the steel-grained iron, under the same circumstances would not melt at all, but pass rapidly into the state of malleable iron.

3rdly, graphite or gray cast iron first makes its appearance by small dark specks inserted on the fracture of the white iron, and at this stage it is said to be mottled when those specks cover the entire surface, and receive, from the addition of more carbon, some degree of lustre, the iron is said to be bright gray; as the fracture becomes more open, and the colour darker, it is called dark gray iron; and when uniformly open throughout with a smooth surface, it is called best foundry iron.

Hitherto it had been supposed and believed that white cast iron contained a much less quantity of carbon—that the change of fracture from white to gray was in consequence of the iron absorbing or becoming united with a large share of that substance—that whatever carbon white iron contained, the graphite was so much in addition, and never considered as a symptom of its abatement.

Dr. Ure, however, holds a contrary opinion; according to him, the greatest quantity of carbon which can be united to the metal is in the state of white iron, and may be to the extent of 5¼ per cent, as the iron becomes more gray by the addition of carbonaceous matter in the furnace, the quantity of carbon in it diminishes inversely to 3⅜ or 4 per cent. This I confess is a paradox of difficult solution, as it involves, to a certain extent, the operation of substracting during a process of repeated additions.

Independent of this, the new theory is to me abundantly perplexing, as the student has to deal with carbon in a considerable variety of states with which he had not been formerly familiar. We have "free carbon, residuum of plumbago and carbon, graphite or plumbago, combined carbon, carbon unaltered, carbon in mechanical mixture, carbon in a state of alteration, &c." The most of this is new and strange to me, but I may inquire whether Dr. Ure ever separated carbon from cast iron by mechanical means that were not magnetic.

Were the new theory true, we should be obliged to abandon the old legitimate conclusion that iron and steel were fusible in proportion to the carbon they contained, but now inversely, seeing white pig iron, which is said to contain the most carbon, is much more infusible than gray iron.

The process of refining pig iron for the manufacture of bar iron, would, under Dr. Ure's system, be no longer a decarbonating operation, but the reverse; for when the gray pig iron introduced into the furnace, had acquired the white or lamellar fracture, it would be found to have absorbed or taken up 1 $\frac{88}{100}$ of carbon in addition, being the difference between 3⅜, the utmost that forge iron may be supposed to contain, and 5¼, the quantity assigned to white iron, and this during an operation of the most severe decarbonization with which we are acquainted.

In like manner, suppose a founder was to charge his air-furnace with 2000 lb. or any other quantity of gray pig iron, which is known to contain 3⅜ per cent. of carbon by repeated fusions, accompanied with a considerable loss of iron, it would at last become possessed of the white or lamellar fracture, and have acquired nearly 2 per cent. more of carbon while passing through a repetition of consecutive fusions. To believe this for one moment appears to me the climax of absurdity.

Again, in the blast furnace a comparatively limited quantity of coke only is necessary merely to fuse the charge, and cause the whole to flow in one common slag, without any portion of the iron being separated. More coke, that is carbon, is added, separation takes place, the iron becomes white, and partakes of the lammelated fracture, and may at that period be supposed to contain the maximum dose of 5¼ per cent. of carbon. The manufacturer, aiming at a more profitable result, adds more and more carbon in the furnace, until he has attained his object as to quality; but, according to the new doctrine, while he has been adding carbon in the furnace, it has been uniformly diminishing in the pig iron.

The pig iron maker might naturally put the following questions: if white pig iron absorbs 5¼ per cent. of the fuel by weight, how is it that this augmentation is not felt in the yield of our ores, but quite the contrary, whereas, when the furnace is making gray iron, the yield from our ores is considerably better?

The operator in the laboratory may be apt to doubt and inquire how it is that, after obtaining his metallic result in white cast iron, and with a fine gloss, he can at any time, by the addition of charcoal, augment the produce of his ore from 1 to 3 per cent. This fact has been known and acted upon by myself for at least 40 years, so that when carburetted results have been obtained beyond the range of the blast furnace, an allowance has been made in the yield of the ore for their extra dose of carbon.

The steel iron maker of Hindostan might well call in question the truth of the new theory upon the most solid and philosophic grounds; for were it so that white cast iron contained more carbon than gray iron, he would decidedly make white iron in preference, for he could do it for for one third of its present cost for charcoal; but he has continued for ages to make gray iron, for the best of all reasons, viz., that his customers can, with gray iron, convert into steel a greater quantity of malleable iron than they can with white.*

On the same grounds I make no doubt that Agricola understood the secret of making iron like the East Indian (gray cast iron), for the purpose of converting, by steeping therein his malleable iron, into steel, and on the same principle, namely, that of its possessing more carbon to communicate to the iron.

I shall, for the present, furnish no further objection to the theory of Drs. Ure and Karsten, but conclude by stating the following facts as being finally conclusive against it:—quantities of gray cast iron, white cast iron, and steel-grained cast iron, were reduced to powder so small as to pass a sieve containing 900 holes in the square inch of its surface, my purpose being to form a species of metallic charcoal to be used in the reduction of an ore of iron, confident that that iron which contained the greatest proportion of carbon would revive from the ore the greatest per centage of iron. A micaceous ore was used in preference, from its presenting more surface to the iron, and which contained 70 per cent. of iron; with the powder made from gray iron 40 per cent. was on the average obtained from the ore, besides making good the weight of the original quantity of iron introduced into the crucible, whereas, when the same experiment was carried into effect with the white and steel-grained iron, not only was there no yield obtained from the ore, but the original iron had sustained a loss varying from 4 to 8 per cent.

I will now make a few final remarks upon the subject of the alleged quantity of carbon contained in steel, on which subject I find my opinions as widely different from those of Drs. Karsten and Ure as upon the proportion which they allege is contained in white cast iron, and which has been alluded to at large in my former communications on this subject.

Dr. Karsten, whom Dr. Ure quotes upon most occasions on the subject of iron and steel, says that he has found the proportions of carbon in steel vary from 1½ to 2¾ per cent.; now in noticing this latter proportion, I have no hesitation in saying that 2¾ per cent. of carbon united with iron would not form steel at all, but white cast iron. Again, it is said that the proportion in blistered steel reaches, sometimes, but never exceeds, 1¾ per cent., so that we are led to infer that some sort of steels contains 1 per cent. more carbon than that which is said to be contained in steel of cementation. According to my knowledge and view of the matter, steel of any sort united with 1¾ per cent. of carbon, would not at any degree of heat extend under the hammer, or be applied to any useful purpose. 1¾ per cent. would be

* See my Papers on Iron and Steel, page 670.

nearly equal to [illegible] part the weight of the iron; now [illegible] part the weight of iron of charcoal fused with Swedish charcoal bar iron on the scale of manufacture, affords cast steel of a very high quality, which requires careful working at a low red heat to convert it into form; any increase of charcoal beyond this proportion would entirely destroy its ductility, either cold or hot. Should an adequate allowance be made for the waste which the charcoal must unavoidably undergo in the crucible, before the affinity is established between it and the bar iron, and for the moisture which, in common with all charcoal, it contains, probably not more than $\frac{1}{4}$ of its weight becomes united to the iron in the process of fusion.

In proof that Dr. Karsten's estimate of the proportions of carbon forming steel is excessive, I refer to the celebrated Bergman's analysis of Swedish steel iron and steel. According to him, the proportion of carbon in steel is (or $\frac{1}{200}$ part) - - ·50

Carbon originally in the iron - ·12

Taken up by the iron in passing into the state of steel, equal $\frac{1}{260}$ part; a proportion very different from those furnished by Dr. Karsten, which range from [illegible] to [illegible] - - ·38

A still less proportion of carbon was found in the laborious analyses of four specimens of French steel iron performed by M. Vauquelin, and which seems to have carried the dose of carbon to the opposite extreme.

*Specimen No.	1,	contained of carbon	·110789
Do.	2	do.	·00683
Do.	3	do.	·00789
Do.	4	do.	·00648

I also subjoin a very accurate and interesting analysis made by Mr. Tennant at Glasgow, and inserted in the 6th volume of the transactions of the British Association, of cast steel made from Danamora iron, which, in point of proportion, coincides with my view of the matter:

Iron	99·288
Manganese	·190
Carbon	·388
Loss	·134
	100· parts.

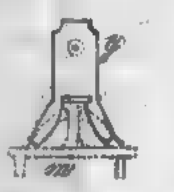
This proportion is equal to $\frac{1}{260}$ part the weight of the steel, and exhibits in a most striking point of view, the minute proportion of carbon which communicates to iron the varied and enduring properties of steel, without which, or some equally powerful substitute, arts and manufactures would soon become stationary.

Your's, &c.,

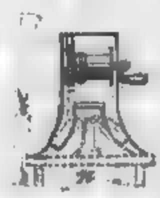
Coleford, June 17. D. MUSHET.

P.S. When Dr. Ure revises the article upon the assay of iron ores, I should recommend him to substitute some other glass or flux for flint glass, as it would be inconvenient and perplexing for the juvenile assayist to have to deal with a button of iron over-riding one of lead, the former containing a little lead, and the latter some iron.

PLATE LAYERS GAUGE LINE.



f, four lengths of 16 feet rails, with the set-ups at *o* and *p*.
o, *p*, the set-ups on the rail with the line fixed, and showing the reel at *p*.
g, *b*, ditto across the ditto.
m, *n*, section of chairs and rail, with the instrument placed.
r, *r*, *r*, top of rail when corrected.



SIR—I take the liberty of handing to you the annexed rough sketch of a plate-layer's line, &c., for the purpose of enabling the plate-layer to keep nearly a correct gradient on the surface of the rails, between two correct heights, at the distance of four or five 16 feet rails. If you think this of any use, or worthy of insertion in your widely circulated Journal, it is at your service, at the same time I beg to say that I am not aware of its ever being applied, but from the best consideration I am able to give on its utility, I am persuaded that it may be applied to advantage, more particularly on railways like the Great North of England, which has so many favourable positions for a great distance in a straight line.

The instrument can be made very portable, and of a light construction, readily fixed on the cheeks of the joint chairs, at any distance required, by merely placing the claws of each set-up on them, no other fastening being required.

One of the set-ups (or gauge) is furnished with a reel and ratch, so that when the line is wound tight, it will be kept from slacking; the line must be made fast to the other 'set-up,' and at equal distance from the top of the rail with the other. When the points at *a* and *e*, (sketch *f*) are connected, the instrument may be then fixed on these places; when the intermediate blocks, &c., at *b*, *c*, and *d*, may be beat up to the proper height, by gauging from the line to the top of rail, (as per dotted line at *f*, *r* 1) the line may be so arranged as to stretch from the points *a* and *e*, on the surface of the rail, and the intermediate rails then brought up to the line, so that no gauging would be required, but I believe the first process would answer the best.

Your obedient servant,

M. Q.

York, June 13, 1841.

If you refer to page 184, I wish you to correct an error in the weight of chairs, &c., the following is the correct statement, and should have been inserted:—

Joint chair	40 lb. each.
Middle	30 „
Check	41 „

M. Q.

CHIMNEY FLUES.

SIR—According to the new Act, chimney flues are, in future, not to be less than 14 inches by 9 inches, or (if cylindrical,) 12 inches diameter. Is this meant to apply to the whole extent of the flue? for if so, all chimney-pots, &c., of less diameter are at once condemned; as far as such unsightly terminations are concerned, that will however be no loss; but as experience has proved that when flues exceed a certain size, contraction becomes necessary, at the top at least, to ensure a good draught, if that is henceforth not to be permitted, the fire-places, in order to contain fire enough to rarify the greater column of air that will thus be exposed to its influence, must be enlarged to an inconvenient extent.

Your opinion on the proper construction of the Act, will oblige your obedient servant,

A SUBSCRIBER.

N.B. According to Tredgold on this subject, flues seldom ought to be more than 8 or 9 inches in diameter, indeed frequently much less; and when climbing boys are no longer permitted, there can be no objection whatever to making them of any size that the particular case may require; and indeed there never was any objection, since there is no necessity, even now, for using so barbarous a mode of sweeping as is about to be forbidden by law.

[We are of opinion that the Act does not apply to chimney-pots—a chimney-pot is not a flue—the flue terminates with the brick shaft.—EDITOR.]

* See Mushet on Iron and Steel, and the quarto edition of Nicholson's Journal.

ON THE BUILDING MATERIALS OF THE UNITED STATES OF NORTH AMERICA.

By DAVID STEVENSON, Civil Engineer, Edinburgh.

Read before the Society of Arts for Scotland in Session 1841.

THERE is, perhaps, nothing connected with the useful arts, which has a greater share in forming the characteristic appearance of a country, than the materials which it produces, and of which its public works are necessarily constructed. I use the word *materials* in the technical sense in which it is employed by engineers and architects, to denote the several productions of the mineral and vegetable kingdoms which are used in the construction of engineering and architectural works; and we have only to look around us for a moment, to be at once convinced how much these, in their almost endless variety, affect the appearance, as well as modify the structure, of the public works of every country.

A good illustration of the truth of this observation presents itself, when we compare the circumstances of Scotland and England in this respect; the former being what may be termed a *stone*, and the latter a *brick* country. To what circumstance can the far-famed beauty of the Scottish metropolis be more reasonably attributed, than to the great abundance of beautiful sandstone afforded by the quarries in its immediate vicinity, to which its street architecture and public buildings are so greatly indebted for their striking appearance. This remark applies, as we are well aware, not only to Edinburgh, but to many other towns in Scotland; while our less highly-favoured neighbours in the south, from the scarcity of good coloured building stone in some districts, and the total want of it in others, are reduced to the necessity of using brick for their dwelling-houses, and in many instances for their public buildings. So generally acknowledged are the fine qualities of the stone from many of the Scotch quarries, that it is exported to a considerable extent. To London itself, indeed, a large quantity of stone is annually sent from Craigleith in Mid-Lothian, which is the largest, and probably the finest sandstone quarry in the world, and of which the dwelling-houses in the New Town of Edinburgh, and most of the public buildings, were in a great measure built.

Many similar illustrations may be found, even in matters of much smaller importance than that to which I have just alluded. In Great Britain, for example, with the exception of some districts in England, the roofs of houses are very generally covered with slates, the greater part of which are supplied by the extensive slate quarries of Bangor in North Wales, and Easdale, Balachulish, and others, on the west coast of Scotland. But Holland has not the advantage of a like supply, and consequently the houses in that country are invariably covered with tiles; and if we extend our observations still further, to Canada and the United States, we there find that the want of more suitable materials for roofing, and the great quantities of fine timber with which those countries abound, have induced the inhabitants to cover their dwelling-houses with wood cut into thin pieces called "shingles," while the spires of the churches, which rise from all the principal towns on the banks of the St. Lawrence, are covered with highly polished tin.

Another of the many illustrations that may be given, appears in the construction of roads—a most important branch of engineering. The roads in this country are now invariably macadamized, as materials hard enough for forming them advantageously on that principle are very generally met with throughout the length and breadth of the island. In France, on the other hand, the want of hard materials renders Macadamizing not so applicable; and consequently, it has not by any means been generally introduced in that country, many of the principal roads being still *pitched* or paved with large stones. In Holland, owing to the scarcity of stones of every description, most of the roads are paved with small well-burned bricks, called "clinkers," which are set in sand, and present an exceedingly smooth surface; while in America and Russia, we find long stretches of "corduroy road," constructed entirely of timber—the produce of their extensive forests, which forms a species of highway by no means so well calculated as any of the others alluded to, for extending communication or promoting the comfort of the traveller; as the painful experience of every one who has travelled on them can abundantly testify.

The materials of every country may therefore be regarded as a subject of great interest connected with its history, and this consideration has induced me to offer a few remarks on the materials employed in the construction of the public works of the United States, in the belief that they may not be uninteresting to the members of a society which has for its object the promotion of the useful arts.

IRON is pretty abundant in North America, and it is worked in several parts of the United States. The only iron-works which I had an opportunity of visiting in the course of a late tour in that country, were those in the neighbourhood of Pittsburg, on the river Ohio, which are said to be the most extensive in America. At this place, the workmen were engaged in the manufacture of pig iron and plate-rails for railroads. The use of plate-rails, however, has been very limited, and as no other description of rail has been manufactured in the country, it has been the practice to import both the rails and chairs for the greater part of the American railroads from Britain, as well as the iron used for some other purposes. The government of the United States, indeed, in order to facilitate the progress of railways, do not exact the duty on iron rails and chairs imported from this country. It may safely be said, that the manufacture of iron in the United States, and what is more closely connected with the subject of this paper, its application to engineering works, are still in their infancy, at least when we regard the great extent and perfection to which these arts have been brought in Britain; and my observations on the materials of the country will therefore be confined to those of masonry and carpentry, as these are in some degree peculiar to the country, and any remarks regarding them will of course be more interesting.

BRICK is the building material which is now invariably used in the construction of dwelling-houses in the towns of the United States. Timber is still pretty generally used for houses in the country; but of late years the erection of wooden structures, from their liability to take fire, has been prohibited in the neighbourhood of towns. Clay suitable for brick-making is found in great quantities, which is a fortunate circumstance for the inhabitants; and the bricks, which are burned with wood, and manufactured in other respects like those in this country, generally cost about 6½ dollars or 26s. a thousand.

Experience in our own and in many other countries, has proved that brick is well suited for house-building; but experience has also shown that it is by no means so well adapted as stone for engineering operations generally; and to some works it is with us considered wholly inapplicable. Marble and granite, of which I shall afterwards have occasion more particularly to speak, occur in the northern parts of the United States; but stone easily accessible to the quarrier, and fitted for building purposes, is very rarely to be met with, and the American engineers have therefore been obliged, as is the case in all countries, to adapt the structure of the works to the materials they possess; and in making this adaptation, they appear to have violated many of the established rules of engineering as practised in this country. The scarcity of stone, and the unsuitableness of brick for hydraulic purposes, for example, has forced them to construct most of the locks and aqueducts on the lines of their great canals wholly of timber, with which the country abounds; and that material, ill adapted as it may seem to such a purpose and situation, where it is not only exposed to the constant tear and wear occasioned by the lockage of vessels, but also to the destructive effects of alternate immersion in water and exposure to the atmosphere, has nevertheless been found in practice to form a very good substitute for the more durable materials used for such works in Europe.

STONE.—The quarries of the United States, taking into consideration the great extent of the country and the number of its public works, are, as I have already hinted, few in number; and, generally speaking, the workings are on a small scale. They afford granite and marble, and their produce is almost exclusively applied to facing public buildings, forming stairs, window and door lintels, and to other architectural purposes.

Granite is worked in the northern part of the country at Quincey in the state of Massachusetts, and at Singsing in the state of New York, and also in New Hampshire. The Quincey granite is of a fine gray colour, and can be quarried in large blocks. It has been used a good deal in Boston and the neighbouring country for architectural works. It has also been employed for railway blocks on some of the lines of railway in the neighbourhood of Boston, and in the construction of the only two graving docks which exist in the United States, the one at Boston, and the other at Norfolk in Virginia, the latter at a distance of upwards of 500 miles from the quarries; and these, so far as I am aware, are the only engineering works of any consequence in America in which granite has been employed.

The Singsing granite, which is of a dark gray or bluish colour, is quarried on the banks of the Hudson, about 25 miles from the town of New York, at which place it has been pretty generally used for some time for stairs and lintels, and has lately been introduced for facing buildings. The Astor hotel, the largest in America, and perhaps in the world, which is one of the very few stone buildings in New York, is built of this granite.

In the neighbourhood of Boston, and also Philadelphia, a species of soap-stone is found, which is quarried to some extent, and used in situations exposed to high temperatures instead of fire-brick.

MARBLE.—To the marble quarries, however, the Americans look for their principal supply of materials. These are more numerous, and are more widely distributed than the others I have mentioned, although they also are confined to the northern states. The principal marble quarries are in the states of Pennsylvania, Massachusetts, and Vermont. I visited some of them when in the country, and had also the advantage of receiving much information regarding them, as well as the materials of the United States generally, from Mr. Strickland, architect, at Philadelphia, and from Mr. John Struthers, marble-cutter, of the same place, to whom I am indebted for the specimens of marbles and woods which I had the pleasure of laying before the Society.*

The marble quarries in Pennsylvania are situate in the valley of the river Schuylkill, and are from thirteen to twenty miles distant from Philadelphia. They produce white, blue, black, and variegated marbles. Limestone is found resting on the marble, and is blasted off with gunpowder, and burned for making mortar. In some of the quarries which I visited, the beds of marble dipped from north to south at an inclination of 60° with the horizon, and they were worked at considerable disadvantage. In one quarry the men were working a bed of white marble 14 feet in thickness, at a depth of 120 feet below the natural surface of the ground. The blocks, some of which weighed 12 tons, were raised to the surface by means of a rudely-constructed horse-gin, there being no road to the bottom of the quarry, or rather pit, from which they are taken, by which even a man could conveniently, or safely, descend or ascend, without the use of a rope to prevent his falling headlong to the bottom. In this respect the American marble quarries reminded me of the celebrated sandstone pits of the ancient city of Caen in Normandy, which are not only remarkable as having produced the materials for the old London Bridge, but as presenting a mode of working very similar to that pursued in the coal-pits of this country; the blocks, being excavated at a great depth under the ground, are conveyed in subterranean passages to shafts, through which they are raised to the surface by horse power, as in the American quarries. The price of the American marble varies according to its quality and kind. The carriage of the materials, owing to the badness of the roads, forms a very expensive item in all the public works, and is, of course, regulated by the distance of transport; but the white marble costs about 4s. 10d., and the blue about 4s. per cubic foot at the quarries, and although this may seem a very moderate price for marble, which in this country costs from 15s. to 2l. a cubic foot, still, when used instead of stone throughout the whole thickness of the wall of a dwelling-house, or the pier of a bridge, it becomes, even at the lower price I have mentioned, a costly material.

The Massachusetts quarries, which are at a place called Stockbridge, produce white and blue marbles, and the Vermont quarries, which are near Lake Champlain, furnish black and white marbles.

Those I have enumerated are the principal quarries in the United States; but from the circumstances of their being so much confined to particular localities, and the manner in which they are worked, it is evident that their produce cannot be applied by any means to the general wants of the country; and consequently, excepting in the case of buildings on which a good deal of money is to be expended, it is but little employed, the cost of the material itself, and the expense of carriage, being very considerable.

The marbles of the United States, according to the account of many intelligent Americans with whom I conversed on the subject, are not suited for sculpture or very fine ornamental works, or even, indeed, for the capitals of columns, which require superior workmanship; and the marble used for the capitals of all the fine buildings throughout the country is imported from Carara in Italy, whence a very large quantity is annually exported to America. For similar purposes black marble is also imported into the States from Ireland. If, however, I might form a judgment from the quality of some of the specimens which I procured, I should think that were the American quarries efficiently worked, there could be very little necessity for applying either to Italy or Ireland for so great an annual supply. Those buildings which are constructed of the whitest description of American marble carefully selected for the purpose, such as the Capitol and the President's house at Washington, the Bank of the United States, the Mint, and other public buildings at Philadelphia, and the monument erected to the memory of Washington at Baltimore, have certainly a most imposing and gorgeous appearance, owing to the fineness and beauty of the material. But the buildings which are constructed of the blue or unselected marble, such, for example, as the State Capitol at Albany, or the Town-House at New York, have a bloated and dingy look, and the general effect produced by the marbles in these buildings is greatly inferior to that of some of the sandstones from Craigleith and other British quarries.

The white marble retains its purity of colour much longer in the United States than it would do in this country, owing to the clearness of the atmosphere and the absence of smoke, the use of anthracite coal, which produces no smoke during combustion, being common in most of the towns. These circumstances may also account for the seemingly permanent vividness of the various colours, such as red, white, brown, yellow, and green, with which, according to the taste, or rather want of taste, of the occupiers, the exteriors of the brick houses in New York, and many other towns in the United States, are generally painted.

TIMBER.—I must now make haste to speak of the materials of carpentry, the other department regarding which I proposed to offer a few remarks.

The forests, to the British eye, are perhaps the most interesting features in the United States, and to them the Americans are indebted for the greater part of the materials of which their public works are constructed. These forests are understood to have originally extended, with little exception, from the sea-coast to the confines of the extensive prairies of the western states; but the effects of cultivation can now be traced as far as the foot of the Allegheny Mountains, the greater part of the land between them and the ocean having been cleared and brought into cultivation. It is much to be regretted that the early settlers, in clearing this country, were not directed by a systematic plan of operations, so as to have left some relics of the natural produce of the soil, which would have sheltered the fields and enlivened the face of the country, while at the same time they might, by cultivation, have been made to serve the more important object of promoting the growth of timber. Large tracts of country, however, which were formerly thickly covered with the finest timber, are now almost without a single shrub, every thing having fallen before the woodman's axe; and in this indiscriminate massacre there can be no doubt that many millions of noble trees have been left to rot, or, what is scarcely to be less regretted, have been consumed as firewood. This work of general destruction is still going forward in the western states, in which cultivation is gradually extending; and the formation of some laws regulating the clearing of land, and enforcing an obligation on every settler to save a quantity of timber, which might perhaps be made to bear a certain proportion to every acre of land which is cleared, is a subject which I should conceive to be not unworthy of the attention of the American Government, and one which is intimately connected with the future prosperity of the country. But should population and cultivation continue to increase in the same ratio, and the clearing of land be conducted in the same indiscriminate manner as hitherto, another hundred years may see the United States a *treeless* country. The same remarks apply, in some measure, to our own provinces of Upper and Lower Canada, in many parts of which the clearing of the land has shorn the country of its foliage, and nothing now remains but blackened and weather-beaten trunks.

The progress of population and agriculture, however, has not as yet been able entirely to change the natural appearance of the country. Many large forests and much valuable timber still remain both in Canada, and in the United States; the Allegheny Mountains, as well as other large tracts of country towards the north and west, which are yet uninhabited, being still covered with dense and unexplored forests.

The timber trade of the United States and of Canada, from the quantity of wood which is required for home consumption and exportation, is a source of employment and emolument to a great mass of the population. It is carried on to a greater or less extent on all American rivers, but the Mississippi and the St. Lawrence are more especially famous for it. The chief raftsmen, under whose direction the timber expeditions on these rivers are conducted, are generally persons of great intelligence, and often of considerable wealth. Sometimes these men, for the purpose of obtaining wood, purchase a piece of land, which they sell after it has been cleared; but more generally they purchase only the timber from the proprietors of the land on which it grows. The chief raftsman and his detachment of workmen repair to the forest about the month of November, and are occupied during the whole of the winter months in felling trees, dressing them into logs, and dragging them with teams of oxen on the hardened snow, with which the country is then covered, to the nearest stream. They live during this period in temporary wooden huts. About the middle of May, when the ice leaves the rivers, the logs of timber that have been prepared and hauled down during winter, are launched into the stream, and being formed into rafts, are floated to their destination. The rafts are furnished with masts and sails, and are steered by means of long oars, which project in front, as well as behind them; wooden houses are built on them for the accommodation of the crews and their families. I have several times, in the course of the trips

* These specimens are now in the museum of the Society of Arts.

which I made on the St. Lawrence, counted upwards of thirty men working the steering oars of the large rafts on that river, from which some idea may be formed of the number of their inhabitants. Those rafts are brought down the American rivers from distances varying from one hundred to twelve hundred miles, and six months are often occupied in making the passage. When it is at all possible, they moor them during the night in the still water at the edge of the river, but when this cannot be done, they continue their perilous voyage in the dark, exhibiting lights at each corner of the raft to warn vessels of their approach to them. The St. Lawrence rafts vary from 40,000 to 300,000 square feet, or from about one to no less than seven acres in surface, and some of them contain as much as £5000 worth of timber. If not managed with great skill, these unwieldy specimens of naval architecture are apt to go to pieces in descending the rapids, and it not unfrequently happens that the labour of one, and sometimes two seasons is in this way lost in a moment. An old and experienced raftsman, with whom I had some conversation on board of one of the St. Lawrence steamers, informed me that he, on one occasion, lost £2500 by one raft which grounded in descending a rapid and broke up. He said the safest size for a raft was from 40,000 to 50,000 square feet, or about one acre, and that five men were required to work a raft of that size.

The species of forest trees indigenous to different countries is an interesting subject connected with vegetable physiology. There are said to be about thirty forest trees indigenous to Great Britain, which attain the height of thirty feet; and in France there are about the same number. But according to the best authorities, there are no less than 140 species which attain a similar height indigenous to the United States.

To notice each of these numerous species, whose timber is employed by the Americans in the arts, even if I were able to do so, would greatly exceed the limits to which I am restricted by the nature of the present communication, and I shall therefore only make a few remarks regarding those timbers which are most highly prized and most extensively used in the ship carpentry and public works of the country.

The first which I shall notice is the Live Oak (*Quercus virens*), so named because it is an evergreen, its leaves lasting during several years and being partially renewed every spring. It grows only in the southern states, and is one of the most valuable of the American timbers. The duty imposed by our government on wood from the United States, prevents its importation into Britain, and as live oak grows only in the United States and is not found in Canada, it consequently never reaches this country as an article of commerce; the whole produce being consumed by the Americans themselves in ship-building. Its specific gravity is equal to, and in some cases greater than, that of water, and it is used along with white oak and cedar for the principal timbers of vessels. The climate, according to an American authority,* becomes mild enough for its growth near Norfolk in Virginia, though at that place it is less multiplied and less vigorous than in more southerly latitudes. From Norfolk it spreads along the coast for a distance of 1500 or 1800 miles, extending beyond the mouths of the Mississippi. The sea air seems essential to its existence, for it is rarely found in the forests upon the mainland, and never more than fifteen or twenty miles from the shore. It is most abundant, most fully developed, and of the best quality, about the bays and creeks and on the numerous fertile islands which lie scattered for several hundred miles along the coast. The live oak is generally forty or fifty feet in height, and from one to two feet in diameter, but it is sometimes much larger, and its trunk is often undivided for eighteen or twenty feet. There can be little doubt, from its great density and durability, that this is one of the finest species of oak that exists, surpassing even that for which Great Britain is so famous. Its cultivation has been tried in this country without success; but could it be imported, it would be found admirably suited for the construction of lock-gates and other engineering works, for which hard and durable timber is required, and for which English or African oak is generally used.

The White Oak (*Quercus alba*) is the species of which so much is imported into this country. It is known by the name of "American oak," but it is a very different and much inferior wood to the live oak of the United States which I have just described. It is also much more widely distributed, and occurs in much greater quantity, than the live oak. It is very common throughout the northern states and in Canada, from whence it is exported to this country. It attains an elevation of seventy or eighty feet, with a diameter of six or seven feet. It is known by the whiteness of its bark, from which it derives its name, and from a few of its leaves remaining on the branches in a withered state throughout the winter. The wood is of a reddish colour, and in that respect is very similar to English oak. But it is generally acknowledged to be greatly inferior to it in strength and durability. It is very straight in the fibre, however, and can be got in pieces of great length and considerable scantling—properties which, for certain purposes, make it preferable to the British oak. It is much used in ship-building, and also for the transverse sleepers of railways. There are many other oaks in the United States, but the two I have mentioned are those most in use.

The pines are perhaps the next woods in importance to the oaks. The species of those are also very numerous, and I shall only mention one or two of the most important of them.

The White, or Weymouth Pine (*Pinus strobus*), is widely distributed both in the United States and in Canada, and is exported to Britain in great quantities from the latter country. It is the tallest tree of the American forest, having been known, according to Michaux, to attain the height of 180 feet. The wood has not much strength, but it is free from knots, and is easily wrought. It is very extensively employed in the erection of bridges, particularly *frame* and *lattice* bridges, a construction peculiar to the United States, and very generally adopted in that country, which I have described in detail elsewhere.* For this purpose it is well fitted, on account of its lightness and rigidity, and also because it is found to be less apt to *warp* or *cast* on exposure to the atmosphere than most other timbers of the country. It is much used for the interior fittings of houses, and for the masts and spars of vessels.

The Yellow Pine (*Pinus mitis* or *variabilis*) occurs only in the southern and middle states, and is not found in Canada, and therefore does not reach this country, the wood known by that name in Britain being the *Pinus resinosa*. It attains the height of 50 or 60 feet, with a diameter of 2 or 3 feet, and is the timber which the Americans employ in greatest quantity for the masts, yards, booms, and bowsprits of their vessels. A large quantity of it is annually consumed for this purpose in the building-yards of New York, Philadelphia, and Baltimore.

The Red Pine (*Pinus resinosa*) is the only other of the pine species that is much used. It occurs in great plenty in the northern and middle states, and in Canada, from whence it is exported in great quantity to this country, and it is known to us by the name of "American yellow pine." It attains the height of 70 to 80 feet, with a diameter of two feet, and is remarkable for the uniform size of its trunk for two-thirds of its height. Its name is derived from the redness of its bark. The wood, owing to the resinous matter it contains, is heavy; and is highly esteemed for naval architecture, more especially for decks of vessels, both in this country and in America.

The Locust (*Robinia pseud-acacia*), from the beauty of its foliage and the excellent qualities of its timber, is justly held in great esteem in America. It abounds in the middle states, and in some situations attains the height of seventy feet, with a diameter of four feet. The wood of the locust tree is of a greenish yellow colour, marked with brown veins, not unlike the laburnum of this country. It is a close-grained, hard, and compact wood, and is of great strength. It is used, along with live oak and cedar, for the upper timbers of vessels, and is almost invariably used for treenails, to which it is well adapted. It is also employed in some parts of the country as transverse sleepers for railways. Its growth being chiefly confined to the United States, it is not imported into Britain. It is one of the very few trees that are planted by the Americans, and may be seen forming hedge-rows in the highly cultivated parts of Pennsylvania.

The Red Cedar (*Juniperus Virginiana*) is another valuable wood, the growth of which is confined to the United States. In situations where the soil is favourable it grows to the height of 40 or 50 feet, with a diameter of 12 or 18 inches. This wood is of a bright red colour; it is odorous, compact, fine-grained, and very light, and is used, as already stated, in ship-building, along with live oak and locust to compensate for their weight. It is considered one of the most durable woods of the United States, and being less affected by heat or moisture than almost any other, it is much employed for railway sleepers. I remember, in travelling on some of the railways, to have been most pleasantly regaled for miles together, with the aroma of the newly laid sleepers of this wood. It is now, however, becoming too scarce and valuable to be used for this purpose.

The White Cedar (*Cupressus thyoides*) and the Arbor Vitæ (*Thuja occidentalis*) are employed for sleepers and other purposes to which the red cedar is applied, but the latter is preferred when it can be obtained.

The only other tree which I shall notice is the Sugar Maple (*Acer saccharinum*) which occurs in great abundance in Canada and the

* The Sylva Americana, by J. D. Browne. Boston, 1832.

* Stevenson's Sketch of the Civil Engineering of North America. London: John Weale, 1838.

northern states. It attains the height of 50 or 60 feet, and is from 12 to 18 inches in diameter. The wood of this tree is soft, and when exposed to moisture it soon decays. It is very close-grained, and when cut in certain directions is remarkably beautiful, its fibres, owing to their peculiar arrangement, producing a surface variegated with undulations and spots. It is also susceptible of a very high polish. These qualities tend to render it a valuable acquisition to the list of American woods for ornamental purposes, for which it is very generally employed, and is well known in this country by the name of "Bird's Eye Maple." The wood of the Red-flowering Maple (*Acer rubrum*) is also employed for ornamental purposes, and is generally known by the name of "Curled Maple." The cabins of almost all American-built vessels are lined with these woods, or with mahogany inlaid with them, and they are also much used for making the finer parts of the furniture of houses.

The property of the sugar maple, however, from which it derives its name, is of perhaps more importance in a commercial point of view than its use as timber. I allude to its property of distilling a rich sap, from which sugar is largely manufactured throughout the United States. From two to four pounds of sugar can be extracted annually from each tree without hurting its growth. I had an opportunity of making some inquiries regarding this simple process when on the banks of the river Ohio, where I saw it in progress. One or two holes are bored with an augur, at the height of about two feet from the ground, and into them wooden tubes, formed of the branch of some soft-hearted tree hollowed out, are inserted. The sap oozing from the maple flows through the tubes, and is collected in troughs. It is then boiled until a syrup is formed of sufficient strength to become solid on cooling, when it is run into moulds and is ready for use.

Such is a brief notice of some of the principal timbers of the United States, which, from their great abundance and variety, are suitable for almost every purpose connected with the arts, and thus serve in some degree to compensate for the want of stone, while at the same time they afford great advantages for the prosecution of every branch of carpentry, an art which has been brought to great perfection in that country. Many ingenious constructions have been devised to render timber applicable to all the purposes of civil architecture, and in no branch of engineering is this more strikingly exemplified than in bridge-building. Excepting a few small rubble arches of inconsiderable span, there is not a stone bridge in the whole of the United States or Canada. But many wooden bridges have been constructed. Several of them, as is well known, are upwards of a mile and a quarter in length, and the celebrated Schuylkill Bridge at Philadelphia, which was burnt about two years ago, but was in existence when I visited the country, consisted of a single timber arch of no less than 320 feet span. Canal locks and aqueducts, weirs, quays, breakwaters, and all manner of engineering works have there been erected, in which wood is the material chiefly employed; so that if we characterize Scotland as a stone and England as a brick country, we may, notwithstanding its granite and marble, safely characterize the United States as a country of timber. I shall only, in conclusion, very briefly allude to the appearance of the American forests, of which so much has been written and said; and on this subject I may remark, that it is quite possible to travel a great distance without meeting with a single tree of very large dimensions; but the traveller, I think, cannot fail very soon to discover that the average size of the trees is far above what is to be met with in this country. I measured many trees, varying from 15 to 20 feet in circumference, and the largest which I had an opportunity of actually measuring was a Button-wood tree (*Platanus occidentalis*) on the banks of Lake Erie, which I found to be 21 feet in circumference. I saw many trees, however, in travelling through the American forests, which evidently far exceeded that size, and which my situation, as a passenger in a public conveyance, prevented me from measuring.

M. Michaux, who has written on the forest trees of America, in speaking of their great size, states, that on a small island in the Ohio, fifteen miles above the river Muskingum, there was a button-wood tree, which, at five feet from the ground, measured 40 ft. 4 in. in circumference. He mentions having met with a tree of the same species on the right bank of the Ohio, thirty-six miles above Marietta, whose base was swollen in an extraordinary manner; at four feet from the ground it measured 47 feet in circumference, giving a diameter of no less than 15 feet 8 inches; and another of nearly as great dimensions is mentioned by him as existing in Genessee; but these trees had perhaps been swollen to this enormous size from the effects of some disease. He also measured two trunks of white or Weymouth pine, on the river Kennebec, in a healthy state, one of which was 154 feet long and 54 inches in diameter, and the other was 142 feet long, and 44 inches in diameter, at three feet from the ground. M. Michaux also measured a white pine which was 6 feet in diameter, and had reached probably the greatest height attained by the species, its top being 180 feet from the ground. It is difficult for an inhabitant of our island, without having seen the American forests, to credit the statements which have been made by various authors, as to the existence of these gigantic trees of 180 feet in height (being about 40 feet higher than Melville's monument in St. Andrew Square, in Edinburgh); but such trees undoubtedly do exist. Mr. James Macnab of the Royal Botanic Garden, in a paper on the local distribution of different species of trees in the native forests of America,* mentions having measured numerous specimens of the *Pinus strobus* in Canada, which averaged 16 feet in circumference, and 160 feet in height; and one specimen which had been blown down, and of which the top had been broken off, measured 88 feet in length, and even at this height was 18 inches in diameter.

The ascent of the sap in trees is a subject which has long occupied the attention of physiologists. Some difference of opinion, however, exists regarding it, and hitherto it is believed no very definite conclusions have been arrived at;—and although not strictly connected with the subject of this paper, I may be excused for remarking, that the quantity of sap required to sustain such enormous trees as these I have been describing, and the source and nature of the power by which a supply of fluid is raised and kept up, at the great height of 180 feet from the ground, are inquiries which, could they be satisfactorily solved, would form most interesting and instructive additions to our knowledge regarding vegetable physiology.

Edinburgh, February, 1841.

ON THE SYSTEM OF WARMING BUILDINGS BY HOT WATER.

A Reply to Mr. Perkins's "Answer" (in the Journal for June last, p. 201,) to the Report presented to the Manchester Assurance Company. By John Davies, and George Vardon Ryder.

Mr. Perkins declaims against our "unfair report;" and charges us with "errors and misstatements," with "manifest absurdity," with "unjust and absurd experiments," "conducted with any view rather than that of candid investigation." Such charges are easily made on either side of a discussion, and are most generally resorted to by those who are least warranted in applying them. We shall presently show how unmerited and irrelevant such charges are in reference to us; and we trust that we shall be enabled to satisfy every disinterested reader, that Mr. Perkins has, in order to conceal the weakness of his defence, indulged his feelings in this kind of phraseology, which, from the facility with which he uses it, seems to be quite natural to him. It usually happens, as in this case, that the use of such language leaves every thing untainted but the reputation of him who utters it; while it forfeits every claim upon an opponent for any greater courtesy of expression in reply than the example would suggest, or the nature of the objections appear calculated to excite.

Our directions, as the reader of the preceding pamphlets will remember, were "to inquire into the *nature of the accidents which have recently occurred* from the use of the hot water apparatus; and to institute a personal investigation into some of the cases referred to; and to make such experiments as might tend to satisfy our minds as to the *causes* of the *accidents which had occurred*" from the use of the apparatus as it has been erected in Manchester, and *not* as it may have been since improved by the Patentee; for the latter being unknown until very "recently," that is to say, until our Report had appeared, it was impossible for us to notice.

We had to investigate the abuses, as well as the uses of the apparatus, as hitherto put up in this town and neighbourhood; for, if the abuses were likely to be of frequent, or even occasional occurrence, if they could arise from ordinary carelessness or mismanagement, it is clear that the danger to property must be very considerable. Of the advantages of Mr. Perkins's "recent" improvement we know nothing excepting what he tells us in his "Answer;" but, how ill soever he may think of us, we do most sincerely assure him, that if it really renders the apparatus secure, we shall hail its application with much pleasure; not altogether with a feeling of satisfaction, resulting from the consciousness that we have hastened, if not occasioned it, by having proved that it was necessary. From his own showing, therefore, Mr. Perkins ought, in this case, to be grateful, rather than angry. We have given to the apparatus a popularity which it did not previously possess, while we have pointed out its defects; these defects Mr. Perkins affirms that he has "recently" completely removed; and, therefore, the very detection of his former errors has tended to diffuse more widely a knowledge of his present state of perfection. Had an "opportunity" been "afforded" to Mr. Perkins "of assisting" us in our "experiments," it is far from probable that he would ever have obtained these advantages, of the source of which he so unreasonably complains.

It seems to be almost impossible to satisfy Mr. Perkins. At first he condemns us because we attended to "appearances;" and he afterwards inveighs

* Agricultural Journal for 1835.

against us because we resorted to "experiments;" it is, therefore, difficult to conceive how we should have proceeded to form our Report, unless by an implicit reliance upon his assertions, which certainly do not, in some cases, rest upon either appearances or experiments.

The great gist of the charges against us is, that we employed in our experiments an apparatus improperly constructed; for he says, "the patentee *utterly disclaims the apparatus experimented upon* by Messrs. Davies and Ryder as his, any further than that the pipes were closed in all parts."—This charge assumes a very imposing aspect; and if we had done designedly that which he here imputes to us, we should indeed have been highly culpable. From a few facts the reader may judge of the truth of the allegation. Mr. Perkins sold some time ago to Mr. Walker the patent right to the apparatus for Manchester and the vicinity. When we were professionally engaged by the Directors of the Assurance Company, we first inspected the premises which had been recently injured; and then, previously to the performance of any experiments, applied to Mr. Walker to see what information or assistance he was able and willing to afford. Mr. Walker acceded, in the most obliging manner, to our application; accompanied us to some establishments where the apparatus was in operation; and promised to get erected on his own premises, and under his own superintendence, a suitable apparatus, on Mr. Perkins's system, for the express purpose of our experiments. Some little delay occurred; and, as it happened, Mr. Walker had in the interval several interviews on the subject with Mr. Perkins, to whom our investigation was no secret! The apparatus was at length put up; the form and the proportion of the parts were precisely those which Mr. Perkins had taught Mr. Walker, and on the same principle which had guided Mr. Walker in others which he had erected, and might be called upon to erect; and was, therefore, in every respect as essentially on "Perkins's System" as any of those which have been yet introduced into any building in Manchester. In short, Mr. Walker made the apparatus; we the experiments. In all the operations we had the assistance of Mr. Walker's intelligent Foreman, and that of other persons belonging to his establishment.

Mr. Perkins does not find fault with 26 feet of coil in the furnace, though he forgets that only 21 feet, as stated, were exposed to the fire, a fact which, being in his favour, he conveniently suppresses; but he seizes with avidity upon a presumed deficiency in the expansion pipe, insisting that from the proportions in the diagram annexed to the Report, it must have been "six inches less than the apparatus required." Now, even in this plausible objection a slight inadvertency on our parts has rendered him unfortunate; for the diagram having been originally drawn from dimensions given by one of Mr. Walker's assistants was, as it happened, six inches less than it was found, on actual admeasurement, to be in the apparatus really employed in the experiments performed.

It is asserted in the "Answer" that "in the *absence of Mr. Walker* a stopcock was introduced, which, cutting off the greater part of the circulation, left only 40 feet of the tubing out of the furnace to carry off all the heat that could be communicated from 26 feet within it." This is a grave charge; but like the others, it rests entirely upon Mr. Perkins's vivid imagination. A reference, however, to our diagram, which, by singular ill luck is, whether correct or incorrect, a stumbling-block to Mr. Perkins, will clearly show that instead of 40 feet of tubing there were 140, with 21 feet only exposed to the action of the fire! As to the stopcock, it is sufficient to remark that it was contrived and attached by Mr. Walker himself!

Mr. Perkins, in his allusions to his safety valve, places himself in an awkward dilemma. Such an addition is either necessary or it is not: if unnecessary, then it renders the apparatus no better than it was previously; but if it is really necessary, what are we to think of the person who has been until "recently" endangering, by his own acknowledgment, in his "some hundreds of apparatus," life and property to an unlimited extent? What are we to think of him who could, knowingly, leave such places as Messrs. Crafts and Stell's unsupplied with an essential protection? Did he carefully and promptly impress Mr. Walker with its great importance?

We have reason to believe that this gentleman was not acquainted with it previously to the publication of our Report. It appears, then, that Mr. Perkins sold for Manchester and the vicinity an apparatus which he has, for some time, known to be dangerous, and against which danger he did not warn either Mr. Walker or his customers until he produced his "Answer" to our statements. The public have, therefore, derived some information from our Report, whatever may be the advantage which the "Answer" has conferred upon its author.

Mr. Perkins rallies us very much for having said that the experiments made at the Natural History Museum, and at Messrs. Vernon and Co.'s, were "unsatisfactory." Whatever may be his opinion, we regard it as unwarrantable to make experiments, even with his apparatus, where other people's property might be endangered. That was, we can assure him, the reason which induced us to afford him this opportunity for the display of his pleasantry.

When he taunts us, so humourously, in reference to the explosion, by saying, to our discomfiture, that "some grey calicoes spread round the furnace were alone wanting to complete the scene, and put the finishing touch to this exquisite specimen of 'Perkins's Hot Water Apparatus,'" he forgets that this experiment was so amply illustrated in the warehouse of Messrs. Crafts and Stell, that it could not, by possibility, be rendered more striking by repetition. This is a portion of his "Answer," in which he is peculiarly jocular; as if the destruction of "grey calicoes" by fire, and the consequent loss of a great amount of valuable property, were a most amusing exhibition. It can only be compared to the case in which Nero fiddled while Rome was burning. This sort of wit may induce an enemy to smile, but it must, certainly, make a real friend look very serious.

An attempted explanation of an unexpected phenomenon is pronounced to be a "manifest absurdity," because, as Mr. Perkins positively avers, "it is impossible that increase of heat can be produced by the condensation or cooling of steam!!" He must surely have intended this statement as a piece of irony to relieve a dull discussion; for, if he had really any doubts upon the subject, he might have easily and readily proved that the very reverse of his assertion is the fact; and if that failed to satisfy him, he might have demonstrative evidence whenever he may pay his contemplated visit to Manchester.

Mr. Perkins might on this point have consulted authority. An author who treats of his system, and with whose work he may be supposed to be acquainted, says, that "the specific heat of condensed steam, compared with [that of] water, is, for equal weights, as ·847 to 1: but the latent heat of steam being estimated at 1000°, we shall find the relative heat attainable from equal weights of condensed steam, and of water, reducing both from the temperature of 212° to 60°, to be as 7·425 to 1."

Mr. Perkins afterwards says, that "another observation from which erroneous conclusions are drawn," (of course from an error in the premises,) "is that the temperature of the pipes, is influenced by the variation of their internal diameter: this is not the case; the amount of heat conducted off depends on the surface exposed to the atmosphere, and not upon the internal diameter:" from which all that can be inferred is, that Mr. Perkins's pipes must be of a very peculiar kind, when, all other things being the same, the internal diameter affords no indication of their magnitude.

Mr. Perkins tries to evade another explanation by the assurance that "the expansive power of hydrogen gas is far less than that of water." Let us examine this singular statement. Professor Graham, of the London University, says, "Hydrogen gas, steam, and the vapour of sulphuric ether, expand in the same proportion as air."—"The expansion by heat of the different forms of matter is exceedingly various. By being heated from 32° to 212°,

1000	cubic inches of iron become	1004
1000	.... water......	1045
1000	.... air........	1375

Gases are, therefore," he adds, "more expansible by heat than matter in the other two conditions of liquid and solid." Thus Mr. Perkins rests his objection on the assumption that 1000 increased by 375 is "far less" than 1000 increased by 45! The reader can now judge for himself how much, in even this simple case, Mr. P. knows of the properties of the agents which his apparatus requires, and of those which it is liable to bring into action.

Mr. Hood, in treating of the hot water apparatus, says that "a most material difference of temperature occurs in the several parts of the apparatus;" a fact, which we have attempted to explain, but the very existence of which Mr. Perkins denies. It is thus accounted for in the work before us:—"The difference, amounting sometimes to as much as 200° or 300°, arises from the great resistance which the water meets with, in consequence of the extremely small size of the pipes, and also from the great number of bends, or angles, that of necessity occur, in order to accumulate a sufficient quantity of pipe."

"We shall find," says the author, "that a temperature of 450° produces a pressure of 420 lb. per square inch, while a temperature of 530° makes the pressure 900 lb.; and when it reaches 560°, the pressure is then 1150 lb. per square inch. Those who are acquainted with the working of steam engines are aware that a pressure of 45 to 48 lb. per square inch is considered as the maximum for high pressure boilers; but we see that in this apparatus the pressure varies from ten times to twenty-four times that amount. It will also be borne in mind that, in consequence of the extremely small quantity of water used in these pipes, the slightest increase in the heat of the furnace will cause an immediate increase in the pressure on the whole apparatus. For it appears that if the temperature of the pipes be increased 50° above the amount before stated, the pressure will be raised to 1800 lb. per square inch; and by increasing the temperature 40° more, the pressure will be immediately raised to 2500 lb. per square inch; so that *any accidental circumstance which, causes the furnace to burn more briskly than usual, may, at any moment, increase the pressure to an immense amount.*"

Mr. Perkins seems, in some allusions, to insinuate an impression on his part, that we entertain towards him something like a feeling of hostility. Any impression of the kind is, we can assure him, completely unfounded. He is entirely unknown to us, excepting in connexion with his system. We were required to investigate his apparatus *as we found it*; and, without any personal consideration, we conducted that investigation to the best of our knowledge and ability.

In conclusion, we beg to assure Mr. Perkins, that if he can really render his "system" safe, we shall, on being satisfied as to the fact, be quite as ready to recommend it, as we have been to warn the public of the danger which might arise from its use in the state in which it was when we were called upon to examine it.

Report of William Fairbairn, Esq.

Having directed my attention to the experiments recently conducted by Mr. Davies and Mr. Ryder on this apparatus, I have been induced further to extend my inquiries, and to visit several establishments where Mr. Perkins's system of heating has been introduced. Amongst others I may mention those of Messrs. Schunck, Mylius & Co., Messrs. Novelli & Albanelli, as

instances where the apparatus has worked satisfactorily for a number of years, and apparently without risk or danger to the buildings. At both places the parties expressed themselves satisfied with the apparatus, and appeared to have no apprehension beyond the alarm and excitement caused by the late accident at Messrs. Crafts and Steil's.

It is true that reflecting persons, and indeed the whole community, have been seriously apprehensive of danger since that accident took place; and Mr. Davies's report, and the opinion of Mr. Ryder, seem conclusive on that point. In fact, it could not be otherwise, as the practical conclusions deducible from the experiments are clear, namely, the singeing of feathers, explosion of gunpowder, charring of wood, &c., are in themselves sufficient evidence of the risk to which the property of individuals is exposed. It is also apparent, that no system of heating is safe where the water, circulating through pipes of small bore, is raised to a high temperature, and subjected to the changes of increased and sometimes suddenly diminished pressure. On this question, therefore, I have no hesitation in giving it as my opinion, that Mr. Perkins's principle of heating is imperfect, and that more particularly from its liability to be overheated, either by improper treatment or a sudden change of temperature, to which the apparatus is at all times exposed.

Mr. Perkins, in describing his apparatus, replies to these objections by stating that, in order to maintain for any length of time an equal temperature, it is only necessary to proportion the furnace to the time the heat is required to be continued, and the damper will regulate the combustion of the fuel, and the heat of the pipes. By this Mr. Perkins means, that the attachment of his heat regulator or governor, as given in his description of the apparatus, will so regulate the admission of air to the furnace, by the expansion and contraction of the flow-pipe acting upon a series of levers, as to open or close the damper according to the temperature or intensity of heat contained in the flow-pipe. Now I have closely examined this part of the apparatus, and although exceedingly ingenious on the part of the projector, it is nevertheless inefficient in its operation upon the furnace, and cannot therefore be depended upon under all the changes to which the whole series is from time to time subjected. Whether this arises from excess of heat in the coils on the one hand, or from a diminution of temperature on the other, is immaterial, as it appears that the apparatus, as now constructed, is liable, either through neglect or otherwise, to almost all the changes of temperature indicated by the experiments of Mr. Davies and Mr. Ryder.

Mr. Perkins, in his description of the apparatus, gives (Mr. Babbage's experiments) the range of temperature in the flow-pipe and chimney as follows:

	Thermometer on Flow-pipe.	Thermometer in Chimney.
	185°	116°
	225	130
	244	132
	249	176
	249	182
	249	178
	249	180
	249	182
	246	184
	247	146
	235	135
	229	202
Giving a mean temperature during a period of 6 hours of........................	238°	162°

Being an exceedingly low temperature, and such as under the regulations prescribed by Mr. Babbage, would be perfectly safe. But comparing the above with the experiments of Mr. Davies and Mr. Ryder, we have the temperature of the flow-pipe equal to that of melted lead, nearly 400° in excess of that which was considered safe by Mr. Babbage. It is clear that in a series of experiments such as those conducted by Mr. Davies and Mr. Ryder, the temperature of the water in the coils and in the flow-pipe, as it issues from the furnace, might be raised to nearly the melting point of iron; but in justice to Mr. Perkins, I am bound to observe, that it is only an experimental case, no doubt carefully and properly conducted, but certainly not indicative of the general working state of the apparatus.

In Mr. Perkins's system of heating there is, I believe, considerable economy, and convenience in its application; it is not, however, the best, nor yet the most wholesome or safe mode of heating. It appears to me to be liable to the following objections:—

1st. The increase of temperature to which the coils and pipes are exposed, and the consequent danger arising from the ignition of flocculent matter, which by accident or neglect might surround the pipes.

2nd. The impurity of the air, caused by its contact with metallic surfaces highly heated.

3rd. Deficient ventilation, where means are not provided for carrying off the impurities, and admitting fresh air at proper intervals.

The above appear to me to be some of the more prominent defects of this system; it is, however, a simple and ingenious apparatus, and provided certain improvements were introduced, I have every reason to believe it might be rendered an agreeable, if not a safe and efficacious mode of heating.

In this country it is obvious that large sums of money have been expended on the use and application of this apparatus: and as numerous buildings, shops, houses, &c., are already fitted with all the necessary furnaces, coils, &c., and as it is impossible to change the apparatus for a better all at once, it appears very desirable to adopt such measures as will prevent the possibility of accident, and afford greater security to property. For these objects I would suggest the attachment of a mercurial tube to the flow-pipes issuing from the furnace, with a metallic piston to rise and fall, and by its action on a throttle-valve damper to check the draught in the furnace, and thus reduce the heat whenever the flow-pipe indicates an excess above the maximum temperature.

Again, I would recommend the flow-pipes to be incased in a perforated iron tube, to a distance sufficient to render a reduction of the temperature certain, and to prevent the possibility of ignition, even when in contact with inflammable matter.

These precautions being adopted, and having encircled the furnace by brick work, I should, under such circumstances, consider the apparatus less objectionable, and freed, in a great measure, from the danger which now surrounds it.

Wm. Fairbairn.

Manchester, April 7th, 1841.

ON VENTILATION OF THE COURTS IN THE OLD BAILEY, LONDON.

On the 6th ult. a Court of Aldermen was held for the purpose of receiving a report from the Gaol Committee on the important subject of the ventilation of the courts of the Old Bailey. Dr. Reid was present during the proceedings.

Sir M. Wood brought up the Report of the Committee to whom it had been referred to consider Dr. Reid's plan for improving the ventilations of the courts of the Old Bailey. The committee were of opinion that the plan ought to be adopted. The committee recommended this Court to direct a communication to the Committee for Letting the City Lands, requesting they will present a report to the Court of Common Council, for authority for the work to be proceeded with under their directions accordingly. Sir M. Wood, in conclusion, moved that the Court agree with the Committee in their Report.

The following is the plan, as described officially by Dr. Reid:—

"My Lord and Gentlemen,

"The defective state of the ventilation at the courts in the Old Bailey, which I have examined according to your instructions, arises principally from the following causes;—

"1. The inadequate supply of fresh air.

"2. The imperfect discharge of the vitiated air, a large proportion of which is returned indefinitely upon the person, instead of being removed with certainty and decision.

"The severity of the currents, arising from inadequate diffusion, and the necessary opening of doors and windows from time to time, when complaints are great from the deficiency in the supply of air.

"4. The imperfect nature of various parts of the apparatus in use, which presents different causes that render the air less wholesome and agreeable than it otherwise would be.

"5. The contamination of the small proportion of air supplied to a great extent with vitiated air, more particularly from the hall and other passages. In the kitchen there is a cesspool having no connexion with any drain, into which about 30 pails of water are introduced daily during the sitting of the Courts, all of which appears, so far as I have been able to ascertain, to mingle by evaporation with the atmosphere of the kitchen, and to find its way to the passages.

"It will be obvious that defects such as these cannot be effectually remedied without introducing arrangements of proportionate magnitude, as in the original construction of the courts, it could not be expected, from the period at which they were built, that provision would be made for meeting the views now entertained as to the nature and importance of ventilation; while the chambers below and above both courts, excepting on the roofs of the New Court, are so much occupied that few facilities are presented for diffusive ventilation, by which alone any degree of comfort can be given in places so liable to a fluctuating attendance as these courts must be. Under the circumstances, and proceeding upon the assumption that 2000 persons are as many as it would be necessary to provide air for, according to the replies to the various inquiries upon which I entered in reference to this point, I have to propose the following arrangements. It may be proper for me to premise, however, that 2000 persons 12 hours a day in court require air for 28,800,000 respirations during that period, independent of what may be necessary for the surface of the body:—

"1. Let a chamber be provided for the reception of fresh air where it shall escape much of the contamination which it receives at present from eating-houses, chimnies, &c., in the immediate vicinity.

"2. Let the air be filtered from soot as it enters the chamber, washed, when necessary with lime-water to remove various impurities, and finally be propelled to the courts by a fanner worked by a steam engine. This arrangement appears to be the only economical plan that will insure the ventilation of the courts, considering the peculiarity of their position, and the manner in which they are hemmed in on all sides by different apartments.

"3. Let chambers be provided below each court, that the air may enter diffusively, and as imperceptibly as possible, the diffusion being regulated by perforated zinc or porous cloth at every place represented by the red dotted line in the plan of the courts.

"4. Let a mild hot water apparatus be procured, and let it be arranged in such a manner that by the mere opening or shutting of a valve, it may be made to afford any proportion of warmth, such as the circumstances of the moment may require. I must here remark, that though ventilation may be induced without warming the air before it enters the court, still the two questions are inseparably connected, more especially as in an apartment not ventilated, the vitiated air stagnated around the person produces part of that warmth which ought to be procured from other sources, and which is required to a greater and greater extent, the more freely the air is supplied. To some constitutions the absence of offensive currents, and the supply of air at a proper temperature, are as important as a supply of pure air.

"5. Let the entrance of the air to the court be regulated by a single valve, so that the amount may be proportioned to the state of the external atmosphere and the fluctuating attendance, so that the effect produced upon the person may in all cases be as nearly as possible the same, whatever changes may ensue, either on the attendance at the court or in the external atmosphere.

"6. Let the foul air also be discharged through a single aperture, a valve being provided there also, to be used under particular circumstances.

"7. One external discharge from each court may be provided, but one alone for both would be preferable, but also more costly, from the cuttings required in the roof.

"8. The external discharge should be protected from the action of currents of air by a cowl, or any equivalent modification of the cowl.

"9. The galleries should be supplied with pure air from the fresh air chamber.

"10. A communication should be established between the cesspool in the kitchen and the adjoining drains.

"All the above points are essentially connected with the ventilation of the courts alone, and would cost, as nearly as I can estimate, about 1,925*l*. In stating this sum, it may be proper for me to mention, that a precise estimate cannot be formed, as the precise facilities or difficulties that may be met with in following out the underground cuttings must necessarily modify the result. But I do not consider that there would be a difference of 100*l*., which might be either less or more than the sum mentioned, according to details that could only be ascertained as the works proceeded. I ought also to observe, that my estimate is founded principally upon the cost of similar works executed in the Queen's Bench and Bail Courts, Westminster, in the Insolvent Debtors' Court, and in various other buildings in London.

"I should not consider the report complete did I not submit for your consideration, that it would be advisable that some minor arrangements should be made for the ventilation of the hall, staircases, and some of the principal apartments in connexion with the courts. In places where the principal room has been ventilated without some attention being paid to lobbies and contiguous apartments, the contrast between the air where ventilation has been introduced and where it has not often leads to complaints that would not otherwise be made, and to the introduction of ventilation in these minor apartments at a future period at a considerable increase of cost. An additional sum of 150*l*. or 200*l*. would enable the ventilation to be greatly improved in all the places now referred to.

"Again, in all buildings constructed in the usual manner there is a defect observed in the movement of air near windows in cold weather, which can be remedied entirely only by double windows; this not being essentially connected with the general arrangements for ventilation, though most important in preventing local discomfort in the seats next the windows, is brought before your notice as a separate question, that can be considered either at present or at a future period.

"Lastly, in making the above report I have to mention, that I have had the advantage of communicating with Mr. Mountague, who has assisted me in obtaining the information required as to the present state of the buildings; and I have the satisfaction to state, that he is of opinion that the several works may be executed without interfering with the character or stability of the building.

"I have the honour to remain, my Lord and Gentlemen,

"Your very obedient servant,

"D. B. Reid."

Sir P. Laurie seconded the motion. He trusted the Court would be unanimous in recommending the adoption of Dr. Reid's plans. It was universally admitted that he had successfully applied them in the ventilation of both Houses of Parliament, an object of paramount importance, which had often been attempted and as often failed. The best evidence that Dr. Reid had been completely successful in his operation on the Houses of Parliament was to be found in the fact that at the conclusion of his labours they had rewarded his talent and perseverance with a complimentary gratuity of 1,000*l*. over and above the stipulated compensation.

The report was confirmed *nem. con.*, so that this complaint will soon be effectually removed.

THE MIASMA OF AFRICA.—NIGER EXPEDITION.

Mr. J. F. Daniell lately read a paper at the Royal Institution, "*On the spontaneous evolution of sulphuretted hydrogen in the waters on the western coast of Africa and elsewhere.*" He commenced by observing, that this subject was now interesting on two accounts—1, because it would recall to the members of that institution the experiments of Sir Humphrey Davy on the subject, and which led him to advise the adoption of ship protectors; and, 2, in consequence of the Niger expedition, fitted out to visit and endeavour to introduce civilization on the western coast of Africa. The effect produced on copper sheathing by the presence of sulphuretted hydrogen in the waters on that coast, was, he premised, well known to every one informed respecting vessels visiting it, and it was a fact that a cruise of nine months on the western coast of Africa injured the copper sheathing of a vessel as much as four years' wear in any other part of the world. The lecturer showed a piece of sheathing taken from the bottom of a Government frigate that had not been many months on the African station, and also a piece from the Royal George, sunk at Spithead, and which had been under water 60 years; the former was eaten through in very many places, and so thin all over that he might push his thumb through it, while the latter was tough and in excellent condition. His attention had been directed to the subject by the Lords of the Admiralty sending him 10 bottles of water, from as many different places on that coast, extending from 8 deg. north of the Equator to 8 deg. south, to analyse, and to report on the component parts thereof, and the accompanying table was the result:—

	Sulphuretted Hydrogen.	Saline Matter.
	Cubic Inches.	Grains.
Sierra Leone, per gallon	6·18	1,696,0
Volta	6·09	2,480,0
Bonny River	1·21	1,788,0
Mooney	..	2,104,0
Gaboon	..	2,169,0
Lobez-bay	11·69	2,576,0
Congo River (Mouth)	0·67	188,0
Congo River (35 miles inland)	..	8,0
Bango	4·35	2,736,0
Lagos	14·75	1,920,0

All the bottles were hermetically sealed, and he had no doubt the water was in every way as good as when taken from the rivers. On drawing the cork, he was immediately struck with the smell of sulphuretted hydrogen, and adopted the general idea that it arose from animal and vegetable decomposition, but it had since appeared to him that such was not entirely the case. The gas extended a distance of 15 or 16 deg., and in some places as far as 40 miles to sea, covering therefore a space of 40,000 square miles. Now what could the origin be? He thought that it arose from the action and reaction of vegetable and animal matter brought from the interior of the rivers upon the sulphates in the sea water. With this idea he gathered last autumn some leaves from a shrubbery and put them into three jars; into one of which he poured some plain New River water, into the second some of the same water in which three ounces of common salt had been dissolved, and into the third the like water, in which some crystallized sulphate of soda was dissolved. To the covers of the jars he fixed inside some litmus paper, and placed them in a cupboard, the temperature of which varied from 70 to 100 or 110 deg. The effect was, that in the first the litmus paper was perfectly white, and the smell by no means unpleasant; in the second the paper was quite white, and the smell similar to that of a preserve; but in the third jar, in which a sulphate was present, the paper was nearly black, and the stench was horrible and nauseous in the extreme, as every one knew the smell of sulphuretted hydrogen gas to be. Now sea-water contained sufficient sulphates to produce this effect, under peculiar circumstances. But a more interesting part of the subject was the miasma so injurious to life on the marshy shore of Western Africa. Some persons said that if science cannot point out a remedy, it is useless to investigate the causes, but he did not so think; if science could not point out a remedy, still it could point to something as a palliation of the evil. The presence of the injurious gas was easily tested by the roughest hand, so that places in which it abounded could be avoided; and if imperative duty rendered it absolutely necessary to go to those places, then plentiful fumigations of chlorine gas would effectually destroy the sulphuretted hydrogen. The effect of this gas was not only visible on the Western coast of Africa, but in many places elsewhere, although not to so great an extent. Might not the jungle fever of India, the periodical fevers of New York and Charleston in America, and the minor diseases on the coast of Essex, be traced to the effects of this deleterious gas? It was a well known fact that the ships in the mouth of the Medway consumed more copper than other ships. Chlorine gas then destroyed the injurious gas, and it was easily made, and the materials very cheap; the Government had plentifully supplied the African Expedition with the materials necessary for the most perfect chlorine fumigations, and he had the pleasure of believing that his report founded on the analysis of the waters submitted to him, and the precautions taken, had imparted confidence not only to the gallant men who composed that expedition, but also to those who had interested themselves in its welfare.

SEVERN NAVIGATION IMPROVEMENT.

(Concluded from page 247.)

Abstract of the Evidence on behalf of the Worcester and Birmingham Canal Company against the Bill for improving the Severn, given before the Committee of the House of Commons on the Bill, May 17, 18, 21, 24, 25, 27, & 28, 1841.

Mr. F. Giles, engineer, examined by Mr. Austin.—I am a civil engineer, and have surveyed many rivers, harbours, canals, and railways. I am acquainted with the Thames, Mersey, Medway, Ayr, and Calder, and many other rivers; I have also planned the construction of works with reference to the Severn; I have surveyed the Severn with reference to the navigation; I then particularly directed my attention to the drainage and scour of the river, as far as they were compatible with the navigation; I surveyed the river in 1837 with Mr. Rhodes' plans; I have surveyed it partially in the present year. I am acquainted with the plan of Mr. Cubitt. Mr. Rhodes' plan was for a ship canal up to Worcester, and a barge canal up to Stourport. [Witness then described Mr. Rhodes' plan.] That plan was not carried into execution. I have heard the whole of the evidence on the present plans. My objections to it beginning at Stourport are to the proposed solid dams; I object to the principle of damming a river permanently. With reference to this river, it will decidedly obstruct the drainage, and be a great bar to the navigation, when there is sufficient depth of water to pass; and I think a different kind of weir could be constructed that would afford the means of passage in low-water season. In the first place, a solid dam must necessarily raise the summer water level to the height of the dam; when the flood is above the summer water level, supposing it to commence as the summer water is now, not impounded (but you can pound it five, six, or seven feet) supposing the flood to commence rising above the artificial sum, if in the first place the flood rises five feet or more above the original summer water, it must rise it also five feet above the artificial sum of water, and so on every flood it must increase with the rise of the flood in the same degree that the summer water is to the flood.

By Mr. Barneby.—My answer does not refer to the river when bank full, but of course it would fill sooner.

By Mr. Austin.—This plan would affect some of the existing drains, particularly that which is made in the sewer at Worcester, and the drainage up the country from the Salwarp to Ombersley. The drainage is about eighteen inches above the low summer water, and of course the dam at Upton must raise the water permanently in proportion to its height, and thus in flood affect the drainage; and that is not all, for the drainage of the gross matter which comes from the sewers of large towns would be collected in pools, which I think would be a very important matter. The Bevere Island dam in like manner would affect the drainage of the Salwarp; for if the water was penned up below the Salwarp, it would be penned up in the Salwarp too. The Salwarp drains an important district, which would consequently be affected. In my opinion, if oblique weirs would pass more water than straight ones, which I do not think they will, it would not the less affect the drainage of the district. Whether oblique or at right angles the permanent height would be the same, and from that I apprehend the effect to the drainage. The deposit would silt upon the upperside of the weir; and I understand this to be the effect at the weirs on the Ayr and Calder, where they have flood-gates which would assist to remove the deposit. I would have the weirs so constructed as to have two, three, or more flood-gates, sixty feet wide, so as to be open whenever freshes come down; I believe this would have a good effect upon the drainage. With any weir there must be a lateral lock, but when the weir was open there would be no necessity for using the lock. I can form but one opinion of the mode in which it is proposed to construct the weirs—and that is, that they must wash away. I have never built one myself but with solid masonry, and with a puddle bank to back it; I believe a footing is absolutely necessary. I don't hesitate to say that it would be most advisable to dispense with weirs between Gloucester and Worcester; I certainly think the experiment should be tried. I would put a weir above Worcester, at the upper end of the pool, opposite the "Dog and Duck;" I would dredge up to this point, through the bridge at Worcester. I think also the dam at Bevere Island should be at the Salwarp. This would render it necessary to sink the soil at Diglis lock, nothing more. The channel-dredging in the river would necessarily lower the water at the wharfs at Worcester, and it would therefore be necessary to dredge up to the wharfs also; this would improve the drainage at Worcester. It would be necessary to have a dam at Worcester bridge, and to underpin the piers. I think the improvements below Worcester should be executed, according to the exigencies of the case, as they presented themselves during the undertaking. I would first proceed to narrow the river to a certain channel in the soft parts by groins, the points of which would form one grooved channel down the river. I should be able to ascertain the force of the scour as the works proceeded, and thus to regulate the extent to which I would apply the operation of dredging. I should dredge at once in the hard shoals with an inclination of four feet to one; I would propose to dredge six feet for the purpose of obtaining five. I should not let my groins run into the river to the full extent at first, but should add to them, if I found it necessary to do so, to maintain the depth. Deerhurst shoal being wholly composed of sand, it would be an interminable task to attempt dredging alone, but with the assistance of the jetties or groins, I think the scour of the river would maintain the depth required. I think Mr. Provis' mode of throwing in stones for the foundation of his side walls a very bad one. I propose in forming my groins to use stakes of larch, lined in the usual way with faggots. My groins will generally be about 120 yards apart. The quantity to be dredged I estimate at 500,000 cubic yards, which, at 1*s.* per yard, would come to £25,000; the groins I estimate at £26,500; and I have put down £6,000 to be spent upon Worcester Bridge, but I think that is much more than will be required, for I believe £1,000 for each pier will be quite sufficient. Then I have set down £10,000 for contingencies (which is more than 10 per cent.) so we will take the total cost, in round numbers, at £70,000. I was employed by the Worcester and Birmingham Canal Company to form a plan of my own for improving the Severn; this was after Mr. Rhodes' plan had been given up. My plan went before Parliament, but it did not pass.

Cross-examined by Mr. Serjeant Merewether.—I cannot tell you the height of the weir in my plan for improving the Severn, but it was up to high water mark. I have this morning had a model brought here, at the request of an hon. member made to me yesterday, but I should like to speak with Mr. Austin before I produce it. [Here a question arose whether the model should or should not be produced. Previous to the termination of the conversation, it was understood that the Committee would re-examine Mr. Cubitt towards the close of the investigation, to hear his answer to the objections which had been made against his plan.] This plan was suggested by me to the Worcester and Birmingham Canal Company, who paid for the surveys and application to Parliament, and who intended to have carried out the improvement by a commission. The toll was to be 2*d.* per ton from Diglis to Gloucester. I have proposed another plan for the improvement, where the toll to be paid was 1*s.* per ton, but that was for a Company, and not in connexion with the Birmingham Canal Company. It was brought forward in opposition to Mr. Rhodes' plan, and when that plan dropped my plan also dropped. I agree with Mr. Walker's regret—as expressed in his report—that so little has been done towards the improvement of the Severn. I do not think that Mr. Cubitt has sufficiently considered the drainage in his plan. I know the situation of Lord Sandys' drain. I went down last Friday night to open it and examine its level, and I knew the drain before. This drain is about 100 yards above Holt Fleet Bridge. The sewer at Worcester, which I mentioned yesterday, has been lately constructed, and I particularly mentioned it because it is the principal one in the city. I was told the fall of that sewer by the person who built it. I am only acquainted with the outfall of that drain. I do not believe the fall is 25 feet. The bottom of the outfall of this drain is 18 in. or 2 ft. above the present low summer level of the Severn, and the sewer is perhaps 5 ft. in height.

By Mr. Godson.—The basin in Lowesmoor is at least 20 feet above the low summer level of the Severn.

Cross-examination continued: I have no doubt but that there is a great fall in that drain. I should think the entrance of the drain may be 20 feet above its outfall. I have not heard of any public meeting of the people of Worcester, in alarm at the effect of the improvement on this sewer, but I have seen a gentleman on the subject. It was Mr. Williams, of the Distillery. He resides on the opposite side of the river to where this sewer enters. Where the water, in consequence of these artificial ponds, stops up the mouths of drains, it must impede the drainage. I do not know the particular effect it may have upon this sewer, because I do not know the fall, but the silt will have a tendency to collect at the mouth, and will certainly be deposited at the foot of the weir. The banks are about 16 or 17 feet above the sewer at Worcester. There is not a considerable fall on the Salwarp a short distance from its mouth; there is only a fall of a few inches about a quarter of a mile up the river. The height of the banks of the Severn near the mouth of the Salwarp is about 15 or 16 feet. I do not know the fall a quarter of a mile further up where the mill is situate. I still say that the valley of the Salwarp would be flooded sooner in consequence of the weir at Bevere Island than it otherwise would be. I have never seen weirs constructed as Mr. Cubitt proposes to construct his, but I still think that his weirs would not stand. Though I know Mr. Cubitt well, and know him to be a man of great experience in these matters, I have no hesitation in saying that I believe him to be wrong in the construction of his weirs, both in the mode of forming them and the material to be employed (red sandstone from Holt and its neighbourhood). I never heard of such a weir giving way, because I never heard of such a weir being constructed. I do not believe that Mr. Cubitt's weir will be water-tight, for I do not think the sheet-piling will be water-tight; and I do think that the water leaping over the sheet piling will blow up the stone-work. I think a single row of sheet piles will not be water-tight. I have never seen a weir on the Taff, and I do not know that there is one there constructed by Mr. Cubitt.

By Mr. Hastie.—I have seen the weir at Hampton Court, but it is not applicable to those proposed to be constructed on the Severn, as it is formed of strong piles, having sluice-boards, and I will undertake to say that it has a solid foundation, either of timber or masonry.

Cross-examination continued.—The placing of rubble stone as an apron in front of the sheet-piling will strengthen the weir, if the piling be water-tight. I shall construct my groins with a slight inclination downwards. My groins will be formed of willow stakes wattled; they will be triangular, the base being against the back of the river, and the apex running into the stream. It is a very old mode of forming groins, and groins constructed in this manner were formerly in the Severn at Upton and near the Ketch. They were removed as a nuisance, because they canted the stream to one side. I mean to construct my groins so as to preserve a continuous channel as much as possible. I have certainly no doubt but that longitudinal walls would get a more perfectly continuous channel than the use of groins, if they could be perfectly formed, which I think could not be the case by dropping in the stones, as proposed by Mr. Cubitt. No doubt it would be a great evil for a boat to strike the point of one of my groins. I do not approve of Mr. Cubitt's proposal to take advantage of the deepest parts of the channel, but prefer dredging a straight channel along the centre of the river. There are five arches at Worcester Bridge, and the centre one is 42 feet wide. The total ascent I have by my plan from Gloucester to Worcester race-course is 6 ft. 4 in. The deepest water is under the centre arch and the one to the left. When the water is low, I do not think there is more than 3 feet under the centre arch. I shall first dredge three arches, then a channel 60 feet wide, through the shoal up the race-course, and subsequently dredge up to the wharfs. When I have dredged through the arches and shoal, I should think all the water will be drawn from the wharfs, as it generally is at present. I have been employed for years by the Worcester and Birmingham Canal Company. I do not know that, in consequence of the boats not being able to unload at the Worcester quays, from want of water, they go into the Birmingham canal to unload. I have not calculated the amount nor the cost

of the dredging along the quays, but I have allowed enough in the £10,000 for contingencies, and in the £6,000 for the bridge. I should think the quays would require under-pinning in consequence of the dredging, but I think the parties connected with them will find it their interest to do it themselves, as the quays are very different to interfering with the bridge, which of course it would be my duty to protect from injury. The surface of the water at the quays will be lowered 5 feet. There will be 19 or 20 feet from the surface of the water, after the bottom has been dredged, to the top of the quays. Below the bridge, there is the wall of the Bishop's Palace, and the Cathedral is not far from the edge of the river; dredging would have the effect of undermining these structures if it were carried close up to them.

Re-examined by Mr. Spooner.—The model I have exhibited does not apply to any part of my plan below Worcester. The groins will be about 50 feet long, by 10 feet wide at the head, and 25 feet at the base or abutment, and packed inside the faggots with hard clay. The channel will not be dredged up to the wall of the Bishop's Palace, but merely in the middle of the river. I am still of opinion, notwithstanding the five hours' cross-examination, that I could successfully dredge up to the Dog and Duck.

By Mr. Barneby.—I do not think the weirs on the Thames are at all applicable to those proposed to be put on the Severn.

Mr. Giles examined by Mr. Lowndes.—There is a lower drain on Lord Sandys' property which is not stated in the section. I have had it opened at various points, and it applies to the under springs. I should say that the outfall of this under drain will be 18 inches below the crown of the pen of water formed by Mr. Cubitt's weir at Bevere Island. The fall of this drain in the first 200 yards is 4 feet. If the present outfall were raised, it would lose the full force which at present exists there. I think the dam at Bevere Island will affect the drainage; about 100 acres of good land are drained by this under drain. The dam at Holt Fleet will affect the drainage of the surrounding land there, which is also very good land. My plan would only raise the level at Salwarp and at Holt one foot, instead of upwards of 4 feet, which it would be raised by Mr. Cubitt's scheme. I see no difficulty in the way of dredging quite up to Holt, and thus have no weir below that point. I think the weirs below Worcester will not only have the effect of affecting the drainage, but also prevent the foul air escaping from the sewers, which would be a great nuisance to the city. The towing paths in the neighbourhood of Lord Sandys' property are very bad. I know of none in such bad condition. I think any plan which would place the river under the control of one body and the towing paths under another must be bad. This inconvenience could be avoided

Cross-examined by Mr. Serjeant Merewether.—I knew the under drain before, but I did not open it till Saturday. In stating that this drain will be 18 inches under Mr. Cubitt's level, I stated on the supposition that there would be 6 inches water on the crown of his weir above the drain. I think that a crust would form in the mouth of the drain, because the floods bring down clay and slime which soon harden.

Mr. W. C. Milne then gave evidence in favour of dredging, which closed the case of the Worcester and Birmingham Canal Company.

Evidence on behalf of the Gloucester Canal Company, and the Corporation of Gloucester.

Mr. Walker examined by Mr. Sergeant Wrangham.—I am a civil engineer of long standing. I was employed to build the Haw Bridge on the Severn 12 or 14 years ago. I also surveyed the river in 1836, and reported upon Mr. Rhodes' plan to the then Severn Navigation Company, by whose chairman, J. W. Lea, Esq., I was employed. I was requested in March last by the Berkeley and Gloucester Canal Company to give my opinion upon Mr. Cubitt's plan. I differ very little with respect to that plan from Mr. Cubitt, up to Upton Ham, except in the details. As we differ so much as to the mode of improving the river above Upton, I should state that Mr. Cubitt proceeds upon the same principle between Gloucester and Upton. I think the river might be made navigable up to Diglis without weirs; and I think it would be a pity to introduce them into so fine a river. My great objection to a lock below Diglis, is, that it would be unnecessary and expensive. I see no reason why the fall from Diglis to Upton could not be practically maintained, as well as the fall below. I do not know any objection to dredging above Upton on account of the hardness of the shoals. It is on account of their hardness they are there, and were they removed the scour of the river would keep the channel clear. If locks and weirs are placed in the Severn, and prove inefficient, I think the matter deposited would be so great in quantity (as in fact the bottom of the river would be then at the top of the weir) that it would be a work of more labour to remove it than to remove the weirs themselves. The shoals formed by the weirs would be greater than the present shoals, but I do not say they would proportionally obstruct the navigation, because the trade will pass through lateral cuts. I am supposing that the bed of the river is formed of gravel and similar substances, which would be washed down in a flood. This in the course of time would have to be removed from the mouth of the cuts by the dredging machine, or else the cuts must be carried further above the weirs. The river below is capable of taking more water than could pass over the oblique weirs, which would consequently be an obstruction. I heard the evidence given in reference to these weirs with great surprise. The only advantage of oblique weirs over others is when little water is coming down, when there would be a thinner sheet of water over the oblique weir than there would be over a cross one, but in a sharp fresh the water would flow over, parallel with the banks, and the oblique weir would not be more advantageous than another. In some instances the oblique weir has an advantage over the direct one, but it is not of more advantage in preventing floods, and I think they would not be so convenient for shooting boats over them in flood time. I think boats would have a greater tendency to capsize over an oblique weir than over a direct one. The expense of my plan up to Diglis would be, including contingencies, £66,000. The cost of maintenance would not be so much as in the plan of Mr. Cubitt; except the lock and weir at Upton, there is not much difference in the expense of our respective plans, so far as Diglis. I see no engineering difficulty in placing the lock at Diglis above the entrance to the Birmingham canal. There is no reason why there should not be steamers up to Worcester all the way from Bristol, so that Worcester may become a little Glasgow. On the Clyde steamers are employed not only to convey passengers, but also to tow up fleets of vessels carrying merchandize. I see no great difficulty in dredging through Worcester Bridge, the only question is the amount of work necessary to secure the foundations, but I think it would be advisable to place the weir a little below the bridge, that there might be an extensive pool opposite the city. On the whole I agree with Mr Cubitt's plan so far as relates to that part of the river between Worcester and Gloucester, with the exception of the solid weirs. In point of fact, if we had an opportunity of consulting together, I think that as repects the whole line there would be little difference between us.

Mr. Walker cross-examined by Mr. Sergeant Merewether.—Were I the friend of Worcester, I should endeavour to prevent six feet being the maximum depth of the improvement of the river. I have taken a great many soundings, but no borings. I think Worcester bridge cannot be built upon a shoal; there is deep water under the arches, and the shoal is below the bridge. I did not say wherever there is dredging there should be walling, but wherever the material is soft it should be walled; but this is not the case above Upton. If the slope of the rubble stone facing is 1½ to 1, it requires packing; but a slope of 3 to 1 would not require packing. I do not know that the Deerhurst shoal has increased; I do not know whether the gravel which is marked in the first section is natural to the place, or has been brought there. The support of each side of the gateway of my weirs would be brace piling. The rest of the river would be occupied by standards about 16 feet apart, and level at least with the top of the proposed weirs, which weirs again would be level with the top of the penned water. There is no reason why the gates should not be raised by machinery, but they are not so in the Thames. If the parties waited till a flood came they could not be moved, and in such case there would be no advantage over the solid weirs. I have seen the Teddington gates partly opened. I think the weeds floating down the stream might have a tendency to fill up the gates. I have made no estimate of the expense of this sort of weir, nor of the expense of attending to or repairing it. I think all the frame-work might be taken out at the beginning of the winter, and put in again about April. While I entertain the opinions that I do at present respecting the improvement of the Severn, I shall always prefer open weirs. No human art can altogether prevent the necessity of dredging in the river. I think a basin at Worcester would be a very desirable thing.

Re-examined by Mr. Sergeant Wrangham.—Since I was examined on Thursday I have carefully re-perused Mr. Cubitt's evidence; and the opinions I then expressed respecting it are strengthened by my having done so. It would be very easy to pick out the weeds from the gates and timbers, much more so than to dredge the deposit at a solid weir. According to my doctrine, if none of the shutters of my weirs could be removed before the flood came, the obstructions would not be greater than by the solid weirs. My weir would cost more *per se* than Mr. Cubitt's; but if you include the dredging that would be required at Mr. Cubitt's weir, mine would be much the cheapest. I think a lock below Worcester would be a great disadvantage to the future navigation to that city; but if it were constructed on my principle I think that inconvenience would be proportionally diminished.

By Sir W. Rae.—The additional expense of dredging by my plan from Upton to Diglis would be £10,640; the expense of walling 4½ miles would be £10,000. I take the whole expense at £25,000 up to Diglis; and there would be £4,600 additional for dredging up to Worcester; £1,600 for walling, and £2,000 for dredging opposite the quays.

By Mr. Barneby.—There would be as much dredging above Worcester bridge if my plan was put in execution.

By Viscount Ingestrie.—The gates of the weir would be ordinarily raised by hand by a person in a boat; I dare say it would take three hours from beginning to end to raise them.

By Mr. Bailey.—The obstruction by a solid weir is 7 times 16, or 112; the obstruction by the open weir would be about one-third of this. There would be no danger in short water of not being able to keep sufficient water for the navigation in consequence of the leakings. I give my plan simply as a general idea; I did not expect to be examined so closely respecting it.

By the Hon. R. Clive.—My honest opinion is that dredging should be first tried for the improvement of the river; if that should fail, a weir of some kind should be tried; but I think they would be the worst friends of the navigation of the river who would recommend the construction of the weirs in the first instance. I think, as I said in my report, it would be very important to try of what the river is capable without locks and weirs.

By an Hon. Member.—There is more tide in the Clyde than in the Severn. The shoals in the Severn would be more difficult to remove than the soft stuff now in the Clyde; but there were originally hard shoals in that river.

By Mr. Godson.—The sum about to be expended upon the Clyde is about half a million. I can't tell what has been expended. Whether the improvement I propose would be worth a shilling a ton to the trade is out of my department to answer; but I think all the trade would be benefitted by it. The Severn will never become so large a navigable river as the Clyde, because the tide does not so much assist it; but I have no doubt it will become a fine river one day. The resistance on any given amount of an oblique weir would be less than on a direct one, but on the whole sum it would be the same. I have seen Mr. Giles's model of a weir. I think there is a complexity about it that should be avoided; it would also be expensive. I don't think walls would be required on both sides the river; two might be injurious. At the time Mr. Smeaton made his survey of the Clyde the shoals were much worse than they are in the Severn.

By Mr. Pryme.—I do not know what the piers at Worcester Bridge are, but I should think the dredging under it could not affect the safety of the bridge.

By Mr. Barneby.—It may be necessary to remove the shoal in the Avon in consequence of the dredging below Upton. Every weir makes as it were a

step in the river; and if you remove it, it would be necessary also to remove the deposit that would be accumulated.

Mr. John Timperley, formerly resident engineer of the Ayr and Calder Navigation, was then called to prove that in that Navigation the oblique weirs were of no advantage, and that dredging to a great extent was still necessary, and was now carried on at a considerable expense. The only portion of his evidence relating to the matter before the Committee was the following:—I do not agree with Mr. Cubitt that in floods the water will pass off just as freely as if his oblique weirs were not in the river at all—it is impossible. I do not think Mr Cubitt's weirs will be nearly strong enough. I have seen a vessel washed over the top of the dam on the Ayr and Calder, and it was not a very unusual occurrence, as they could not always stop the boat; the rope might slip or break, and then the boat would go over the dam. I have not examined the Severn, but from what I have heard, I have no doubt the river might be improved up to Worcester without weirs. If weirs are used they should not be solid.

Cross-examined by Mr. Talbot.—I only know personally about the Severn, from having once driven over the Haw Bridge. There are many mills on the Ayr. The weirs were originally put in to keep up the water for the mills. There are dam boards in these weirs, and if there is a heavy fresh it is difficult to remove them. They require repairing sometimes. The Calder is a tortuous river.

Re-examined by Mr. Wortley.—The Calder is a tortuous river, but the Ayr is not.

By Mr. Godson.—The water at the highest floods goes straight over the weir, but it goes at right angles when it is a moderate stream; at six or seven inches water it goes at right angles, but at six or seven feet it goes over straight. I agree with Mr. Walker that it is possible, after dredging up to Worcester to the depth of six feet, further to improve the river so that ships might come up. I do not know the exact depth of the Gloucester & Berkeley Canal.

By Captain Winnington.—I believe that the Ayr and Calder Navigation is not wider above the oblique weirs than at any other part.

Mr. Fulljames, examined by Mr. Wood. I am an architect and engineer, and am surveyor to the county of Gloucester. I have erected a bridge over the Isis, superintended the removal of the old Over Bridge, and have put up large flood-gates on the Severn six miles above Gloucester, &c. I have been employed by the landowners between Worcester and Gloucester to oppose this measure, and have made observations accordingly. There are about 20,000 acres between Worcester and Gloucester under flood water-mark, (or the level of the banks,) and the parties employing me own about half that quantity. I have been used to the Severn all my life, and from observations made during the last ten or fifteen years, I find that, on an average, there is one summer flood in five years, three land floods per annum, and three winter floods in two years. Summer floods are wholly injurious, and so are back water or land floods, but the winter floods are sometimes useful, inasmuch as they deposit a sediment which is beneficial. In 1830 the whole crop of hay on this extent of land was either carried away or destroyed. The loss was about 3*l*. per acre, and nearly the whole tract is grass land. I believe that the weir at Upton would cause a flood to overflow these low lands for miles, which would not rise above the banks if there were no weir there. [Here the witness stated, in answer to various questions, that he entirely agreed with Mr. Walker's evidence, and on Mr. Pryme informing Mr. Wood that the weir at Upton was abandoned, he turned his attention to the improvement as effected by dredging up to Diglis.] I do not approve of Mr. Cubitt's mode of dredging, because he does not take the centre of the stream, as proposed by Mr. Walker; by dredging near the banks they would be liable to slip in. I do not approve of the mode of forming the side walls, because there would not be enough stuff to fill up the space between the walls and the banks. I should not recommend the landowners to assent to Mr. Cubitt's plan of dredging up to Diglis, supposing that the weir was not put in at Upton. Mr. Fulljames was further examined, but his evidence mainly coincided with that of Mr. Walker.

Cross-examined by Mr. Craig.—The 10,000 acres I spoke of are subject to floods. I think about 200 of them belong to Mr. Hyett. They are about ten miles from the proposed weir at Upton Ham. Part of them are 1½ mile from the Severn. About 600 acres belong to Mr. Fulljames, a near relation of mine. About 158 acres belong to Mr. Yorke. They are all below flood mark, and are 5 miles below the proposed weir. The witness was examined at considerable length, but his evidence was merely a repetition of what has been already published in that of other witnesses. In answer to questions by Sir W. Rae he said:—By doing away with the weir at Upton, steam tugs could come up to Diglis. Vessels tugged by a steamer would require three men for general purposes. Steam boats have been tried on the river, but were discontinued for want of water.

Mr. Cubitt was recalled by the Committee, and confirmed his former evidence. In answer to questions by Mr. Bailey, he said—I am not aware of the length of the drains of Worcester nor of the fall.—(Mr. Bailey then stated the dimension and fall.) I do not think, if such is the dimension and fall, our works will affect it. I think covering up the mouth of the drain would be beneficial rather than otherwise, as it would prevent the effluvia from reaching the city. It is possible to widen the river to so great a width and to put in a weir across it at so great a length that it shall be able to take the whole water of the river at summer time or flood time: therefore, assuming I make a weir of great length across the bed of the river, and widen out the river to admit free access to the weir, and make the weir so long that six inches of water along the weir should be of a sectional area equal to the whole of the river, of the same height above and below the weir; and it must be evident to those who think about it, that there is as much water way at the height of two feet six inches as in any cross section of the river above or below, at any dead level. It is, therefore, possible to make a weir which shall be an obstruction to a certain height, and after that height shall be no obstruction. The merit of the weir consists not in its obliquity but its length. (Mr. Cubitt then produced a model to show the amount of obstruction that would be occasioned by the weirs, the details of which he explained to the Committee.) He also said that he could put weirs in the river, either oblique or direct, which would not affect the stream at all; others might say it could not be effected, but it was a fact which could not be affected by their statements. I could produce a model in which water could pass over a weir, but I have an objection to do so, since they never act well on any scale. I have heard dredging down the centre of the stream mentioned as preferable to my plan; my only objection to it would be its expense; I kept expense constantly in view in my arrangement. I said in my cross-examination that it was feasible to dredge up to Worcester. We could sooner build a lock and weir at Upton than we could dredge from Upton to Worcester; dredging would take one season more. It does not appear to me that there is any material objection to that plan being followed. It would be impracticable to dredge from Worcester to Stourport: millions might do it, but hundreds of thousands would not; it would be quite out of question to dredge to the Dog and Duck on account of the fall. With six feet navigation over the lock sills, vessels from 80 to 120 tons could come up from the sea, through the Gloucester and Berkeley Canal, up to Worcester and Stourport; steam boats could pass through the locks without difficulty. If the bill passed I should be content to confine myself to one lock and weir this winter, and in the spring I would commence the others together. I think it would be best to commence below Worcester; I would engage to get the Diglis lock completed before Christmas. Suppose the bill passed, omitting the Upton weir, I would put all the lower Severn in a fit state for dredging by that time. I would finish the Diglis lock and weir at the same time; and I would be content that further operations should depend upon the effect of these works.

By Mr. Lowndes.—I admit the level near Lord Sandys's drain may be raised 18 inches.

Mr. Cubitt and Mr. Giles then entered into mutual discussion and explanation as to the effect of the works upon the drainage at Holtfleet and the Salwarp, when it appeared that in consequence of the section being very small, Mr. Giles had supposed the line representing the level formed by the Bevore Island weir to be horizontal, whereas in fact it sloped one inch per mile.

The Committee came to the following resolution:—

"That the preamble of the Bill is proved;" and then proceeded to consider the Bill clause by clause. The Bill was ultimately postponed until next Session, in consequence of the early conclusion of the Session.

REVIEWS.

The True Principles of Pointed or Christian Architecture: set forth in Two Lectures, delivered at St. Marie's, Oscott. By A. WELBY PUGIN, Architect and Professor of Ecclesiastical Antiquities in that College. Small 4to. London: J. Weale, 1841.

That this new work of Mr. Welby Pugin's will excite much interest, both among his professional brethren, and amateurs, may be confidently pronounced by us beforehand, since whatever comes from him must command attention; but that it will please every one is more than we dare assert; or rather we are certain that a good deal in it will prove unpalateable to a good many folks. By not a few, this volume—and a very handsome and tasteful volume it is—will be opened with anxious misgivings and apprehensions for themselves and their productions, since Mr. Pugin is known to be a tolerably plain-spoken man, and if anything rather overstrict than at all lax in his critical opinions. He is not one of those who keep beating about the bush, who fearful of giving offence, or of being thought too severe, rather hint at than utter what may be unpalateable truths. On the contrary, he gives free utterance to what he thinks, and he both thinks and speaks to the purpose; consequently what he does say must on that very account be all the more provoking to those who would be exceedingly glad to be able to gainsay not a little that his book contains.

Among the malcontents will be those who have been taught, or who teach others to look upon *classical* architecture, as the very perfection of the art—as its culminating point both in taste and genius, and who even consider it to be the highest merit of us moderns to be able to transplant a portico from a Grecian or Roman temple. The following extract will at once convince our readers, that Mr. Pugin will scandalize those whose orthodoxy is of the above kind.

Grecian architecture is essentially *wooden* in its construction; it originated in wooden buildings, and never did its professors possess either sufficient imagination or skill to conceive any departure from the original type. Vitruvius shows that their buildings were formerly composed of trunks of trees, with lintels or brestsummers laid across the top, and rafters again resting on them. This is at once the most ancient and barbarous mode of building that can be imagined; it is heavy, and, as I before said, essentially wooden; but is it not extraordinary that when the Greeks commenced building in stone, the *properties of this material did not suggest to them some different and improved mode of construction?* Such, however, was not the case; they set up stone pillars as they had set up trunks of wood; they laid stone lintels as they had laid wood ones, *flat across;* they even made the construction appear still more similar to wood, by carving triglyphs, which are merely a representation of the beam ends. The finest temple of the Greeks is constructed on the *same principle* as a large wooden cabin. As illustrations of history

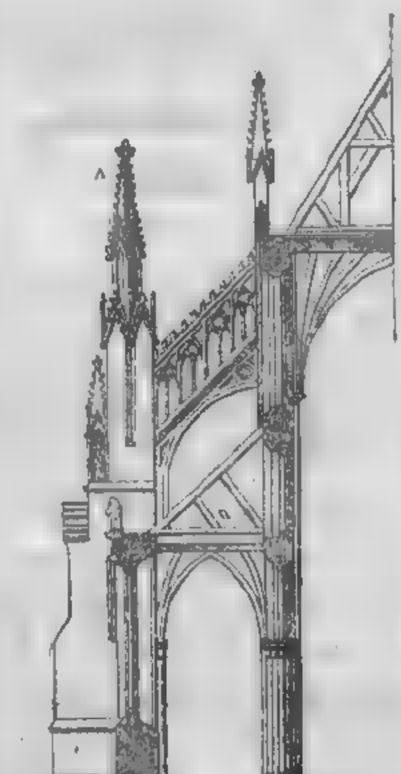
they are extremely valuable; but as for their being held up as the standard of architectural excellence, and the types from which our present buildings are to be formed, it is a monstrous absurdity, which has originated in the blind admiration of modern times for every thing Pagan, to the prejudice and overthrow of Christian art and propriety.

The Greeks erected their columns, like the uprights of Stonehenge, just so far apart that the blocks *they laid on them would not break by their own weight.* The Christian architects, on the contrary, during the *dark ages,* with stone scarcely larger than ordinary bricks, threw their lofty vaults from slender pillars across a vast intermediate space, and that at an amazing height, where they had every difficulty of lateral pressure to contend with. This leads me to speak of buttresses, a distinguishing feature of Pointed Architecture, and the first we shall consider in detail.

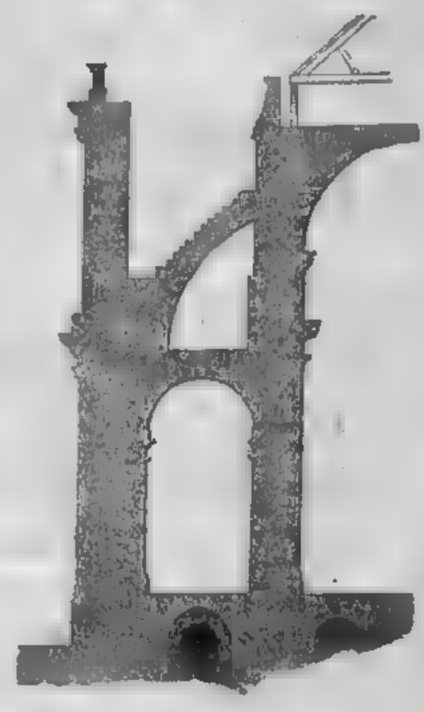
It need hardly be remarked that buttresses are necessary supports to a lofty wall. A wall of three feet in thickness, with buttresses projecting three feet more at intervals, is much stronger than a wall of six feet thick without buttresses. A long unbroken mass of building without light and shade is monotonous and unsightly; it is evident, therefore, that both for strength and beauty, breaks or projections are necessary in architecture. We will now examine in which style, Christian or Pagan, these have been most successfully carried out. Pointed architecture does *not conceal her construction, but beautifies it:* classic architecture seeks to conceal instead of decorating it, and therefore has resorted to the use of engaged columns as breaks for strength and effect;—nothing can be worse. A column is an architectural member which should only be employed when a superincumbent weight is required to be sustained *without the obstruction of a solid wall;* but the moment a wall is built, the *necessity and propriety of columns cease,* and engaged columns always produce the effect of having once been detached, and the intermediate spaces blocked up afterwards.

A buttress in pointed architecture at once shows its purpose, and diminishes naturally as it rises and has less to resist. An engaged column, on the contrary, is overhung by a cornice. A buttress, by means of water tables, can be made to project such a distance as to produce a fine effect of light and shade. An engaged column can never project far on account of the cornice, and all the other members, necessarily according with the diameter of the column, would be increased beyond all proportion. I will now leave you to judge in which style the real intention of a buttress is best carried out.

I have yet to speak of flying buttresses, those bold arches, as their name implies, by which the lateral thrust of the nave groining is thrown over the aisles and transferred to the massive lower buttresses. Here again we see the true principles of Christian architecture, by the conversion of an essential support of the building into a light and elegant decoration. Who can stand among the airy arches of Amiens, Cologne, Chartres, Beauvais, or Westminster, and not be filled with admiration at the mechanical skill and beautiful combination of form which are united in their construction? But, say the modern critics, they are only props, and a bungling contrivance. Let us examine this. Are the revived pagan buildings constructed with such superior skill as to dispense with these supports? By no means; the clumsy vaults of St. Paul's, London, mere coffered semi-arches, without ribs or intersections, *have their flying buttresses; but as this style of architecture does not admit of the great principle of decorating utility,* these buttresses, instead of being made *ornamental, are concealed by an enormous screen,* going entirely round *the building. So that in fact one half of the edifice is built to conceal the other.*



Section of a Pointed Church, with the Flying Buttresses decorated.



Section of St. Paul's, London, a Church built in the revived Pagan style, with the Flying Buttresses concealed by a Screen.

Although we will not go so far as to say it is inconsistent with correct principles of taste to introduce columns merely for the sake of decoration,—a doctrine which if consistently and strictly followed up, would put us out of conceit with the ornamental parts of many Gothic structures also;—we certainly do agree with Mr. Pugin in the main. Beautiful as we consider Grecian architecture to be as regards its mere forms, we have always felt it to be exceedingly *borné* and limited in expression. The whole of it lies in a very narrow compass; it admits of scarcely any combinations; it may, in fact be said to be stereotype. Like a barrel-organ it can play only a single set of tunes, which however agreeable they may be at first, become tiresome by repetition. Antiquarian travellers visit Lycia and other parts of Asia Minor, and merely return with *mare's-nest* discoveries of what we may find just as well, in our own libraries and portfolios; or if they do chance to meet with something like a new idea for a column or capital, scarcely ever is it turned to account, but we go on with our hackneyed Ilissus Ionic, &c., *usque ad nauseam.*—But we are now *improving* upon Mr. Pugin, so let us cut short our own remarks, and return to him and his book.

As it will, doubtless, be ere long in the hands of most of our readers, who will then have the advantage of the numerous illustrations as well as the whole of the text, we shall not attempt to follow its author step by step; therefore, passing over many clever original remarks in regard to 'mouldings,' and the 'use of the splayed form,' &c., we shall notice his free animadversions on the preposterous absurdities passed off by fashionable upholsterers, cabinet-makers, and paper-hangers as

Gothic furniture and Gothic patterns, in the true Brummagem gusto; illustrating some of these mongrel monsters by specimens in his engravings and cuts,—among the rest, of a "New Sheffield pattern for a modern *Castellated Grate!*"

"Modern grates," he observes, "are not unfrequently made to represent diminutive fronts of castellated or ecclesiastical buildings with turrets, loopholes, windows, and doorways, all in a space of forty inches.

"The fender is a sort of embattled parapet, with a lodge-gate at each end; the end of the poker is a sharp pointed finial; and at the summit of the tongs is a saint. It is impossible to enumerate half the absurdities of modern metal-workers; but all these proceed from the false notion of *disguising* instead of *beautifying* articles of utility. How many objects of ordinary use are rendered monstrous and ridiculous simply because the artist, instead of seeking the *most convenient form*, and *then decorating it*, has embodied some extravagance *to conceal the real purpose for which the article has been made!* If a clock is required, it is not unusual to cast a Roman warrior in a flying chariot, round one of the wheels of which, on close inspection, the hours may be descried; or the whole front of a cathedral church reduced to a few inches in height, with the clock-face occupying the position of a magnificent rose window. Surely the inventor of this patent clock-case could never have reflected that according to the scale on which the edifice was reduced, his clock would be about two hundred feet in circumference, and that such a monster of a dial would crush the proportions of almost any building that could be raised. But this is nothing when compared to what we see continually produced from those inexhaustible mines of bad taste, Birmingham and Sheffield: staircase turrets for inkstands, monumental crosses for light-shades, gable ends hung on handles for door-porters,(?) and four doorways and a cluster of pillars to support a French lamp; while a pair of *pinnacles* supporting an arch is called a Gothic-pattern scraper, and a wiry compound of quatrefoils and fan tracery an abbey garden seat. Neither relative scale, form, purpose, nor unity of style, is ever considered by those who design these abominations; if they only introduce a quatrefoil or an acute arch, be the outline and style of the article ever so modern and debased, it is at once denominated and sold as Gothic.

"While I am on this topic it may not be amiss to mention some other absurdities which may not be out of place, although they do not belong to metal-work. I will commence with what are termed Gothic-pattern papers, for hanging walls, where a wretched caricature of a pointed building is repeated from the skirting to the cornice in glorious confusion,—door over pinnacle, and pinnacle over door. This is a great favourite with hotel and tavern keepers. Again, those papers which are shaded are defective in principle; for, as a paper is hung round a room, the ornament must frequently be shadowed on the light side.

"The variety of these miserable patterns is quite surprising; and as the expense of cutting a block for a bad figure is equal if not greater than for a good one, there is not the shadow of an excuse for their continual reproduction. A moment's reflection must show the extreme absurdity of *repeating a perspective* over a large surface with some hundred different points of sight: a panel or wall may be enriched and decorated at pleasure, but it should always be treated in a consistent manner."

These cavalier censures will hardly obtain for Mr. Pugin the good-word of the honourable company of Paper-Stainers and Paper-Daubers. It may reduce the value of their stock on hand, and also of that of the Sheffield and Brummagem artists, at least 75 per cent.; but let them and Messieurs the upholsterers plaister up their pique with the comfortable reflection that, as many people will now be ashamed of their trumpery *Gothicisings*, and proceed to get rid of them as fast as they can, they must have their rooms refurnished,—which will, of course, be all for the benefit of trade.

In his second lecture he again touches upon the subject of furniture, and has another slap at the Upholsterers; who

"Seem to think that nothing can be Gothic unless it is found in some church. Hence your modern man designs a sofa or occasional table from details culled out of Britton's Cathedrals, and all the ordinary articles of furniture, which require to be simple and convenient, are made not only very expensive but very uneasy. We find diminutive flying buttresses about an arm chair; every thing is crocketed with angular projections, innumerable mitres, sharp ornaments, and turreted extremities. A man who remains any length of time in a modern Gothic room, and escapes without being wounded by some of its minutiæ, may consider himself extremely fortunate. There are often as many pinnacles and gablets about a pier-glass frame as are to be found in an ordinary church, and not unfrequently the whole canopy of a tomb has been transferred for the purpose, as at Strawberry Hill. I have perpetrated many of these enormities in the furniture I designed some years ago for Windsor Castle. At that time I had not the least idea of the principles I am now explaining; all my knowledge of Pointed Architecture was confined to a tolerably good notion of details in the abstract; but these I employed with so little judgment or propriety, that, although the parts were correct and exceedingly well executed, collectively they appeared a complete burlesque of pointed design."

This last confession is highly creditable to Mr. Pugin. Such a frank avowal of his own artistical delinquencies, speaks much in his favour, and shows that if he is severe towards others, he cannot be reproached with being over-indulgent towards himself. At the same time we must say that if the censures he levels against architects and their employers be for the most part well merited, they are occasionally too sweeping and overstrained. His objections, for instance, against the application of the Italian style, to domestic architecture in this country, amount to little more than a sophistical tirade. "What," he asks, "does an Italian house do in England?" Which question put forth by him as an unanswerable one, might be turned against the cause he himself advocates; for just as well might it be asked, on the other hand, why should a house erected in the reign of Queen Victoria, be made to resemble one built in the time of Edward IV., or, Henry VII. or VIII? Why should a Protestant church of the 19th century be in any respect modelled like a Roman Catholic one of the 14th or 15th? Is not the Italian style to the full as applicable to our actual wants and purposes in the majority of cases, as any mode *borrowed*—for borrowed after all it must be—from examples to be found, indeed, in our own country, but belonging to periods more dissimilar from, than in aught resembling the present one? Nominally Italian as to design, are not Barry's two Club-houses in Pall Mall, perfectly English in their accommodation? We could easily extend this list of questions; but until they are answered they will answer for the present occasion. Even our ancestors themselves were addicted to change: they endeavoured to make their buildings keep pace with the progress of social improvement and the spirit of the times. Nay, *mutatis mutandis*, what Mr. Pugin himself urges against the castellated style might in some degree be objected to some other styles of much later date.

"What can be more absurd than houses built in what is termed the castellated style? Castellated architecture originated in the wants consequent on a certain state of society; of course the necessity of great strength, and the means of defence suited to the military tactics of the day, dictated to the builders of ancient castles the most appropriate style for their construction. Viewed as historical monuments, they are of surprising interest, but as models for our imitation they are worse than useless. What absurdities, what anomalies, what utter contradictions do not the builders of modern castles perpetrate! How many portcullises which will not lower down, and drawbridges which will not draw up!—how many loop-holes in turrets so small that the most diminutive sweep could not ascend them!—On one side of the house machicolated parapets, embrasures, bastions, and all the show of strong defence, and round the corner of the building a conservatory leading to the principal rooms, through which a whole company of horsemen might penetrate at one smash into the very heart of the mansion!—for who would hammer against nailed portals when he could kick his way through the green-house? In buildings of this sort, so far from the turrets being erected for any particular purpose, it is difficult to assign any destination to them after they are erected, and those which are not made into *chimneys* seldom get other occupants than the rooks. But the exterior is not the least inconsistent portion of the edifices, for we find guard-rooms without either weapons or guards; sally-ports, out of which nobody passes but the servants, and where a military man never did go out; donjon keeps, which are nothing but drawing-rooms, boudoirs, and elegant apartments; watch-towers, where the housemaids sleep, and a bastion in which the butler cleans his plate: all is a mere mask, and the whole building an ill-conceived lie."

We would give a trifle to know what is Mr. Pugin's opinion of Windsor Castle;—in fact we should very much like to see a volume of comments from his pen relative to some of the principal modern Gothic structures he has examined in various parts of the country. We do not imagine that he is perfectly satisfied with any one of them—not even with Windsor itself; still, they cannot all be equally bad: some must possess more or less merit in particular parts, or else be conspicuous for egregious sins and defects; and at any rate, we should then obtain something in the shape of specific criticism from Mr. Pugin, instead of those generalized observations to which he has hitherto chiefly confined himself. In the meanwhile, we thank him for the present work, from which much profitable instruction is to be obtained. Considerable praise is also due to the publisher, for the truly elegant manner in which the volume is got up, so as to render it one well fitted not only for the library, but the drawing-room and boudoir; nor is it deficient in the popular recommendation of being unusually cheap.

History of Belvoir Castle, from the Norman Conquest to the Nineteenth Century; with a Description of the Present Castle, and Critical Notices, and the Paintings, &c. &c. By the REV. IRVIN ELLER, of Queen's College, Cambridge. 8vo. London, 1841.

We shall confine ourselves to the latter half of this volume, namely, the description of the Castle itself and its apartments, as being that which more properly comes under our cognizance, and which is most to our individual taste. From the first or historical part we content

ourselves with gathering the following notices in respect to the building. After being wantonly laid in ruins by Lord Hastings, on whom it had been bestowed by Edward IV., the Castle was begun to be rebuilt in the reign of Henry VIII, by Thomas, first Earl of Rutland, and was completed by Henry, the second Earl, about 1555. It was afterwards dismantled by the Parliamentary forces under Cromwell, and again rebuilt in 1668. Excepting some slight alterations, such as the addition of a picture gallery, made by George, the third Duke of Rutland, about 1750, the structure underwent little change until the beginning of the present century, when the new works were commenced in 1801, and carried on under the direction of Wyatt till 1816, at which time the south-west and south-east fronts were completed, and the grand staircase and picture gallery in the north-west one nearly finished. On October 26th of that year a most calamitous fire broke out,* which consumed the whole of the north-west and north-east sides, and would probably have extended its ravages further, had it not been arrested by bricking up the doorway opening from the grand staircase into the Regent's gallery, which, with the chapel, form the south-west front of this extensive pile. Of the pictures destroyed we have here a complete catalogue, with the sums at which each was valued—varying from 5*l.* to 3000 guineas—and those for which each was insured. Among them were a great many family portraits by Sir Joshua Reynolds, and his large picture of the Nativity, painted for the centre compartment of the stained glass window in New College, Oxford.

After this event the north-east and north-west fronts were rebuilt under the direction of the Rev. Sir John Thoroton,† an amateur architect, who appears to have greatly improved upon the ideas of his professional predecessor, notwithstanding that the latter was no other than the "celebrated" Wyatt. One very material improvement on the original plan, both as regards external appearance, convenience, and internal effect, adopted by Sir John—is the grand entrance in the north-west front, consisting of a spacious advanced carriage porch, connected with the building by a short corridor forming an approach to the vestibule or "guard-room;" whereas, previously to the fire, there was nothing, whatever of the kind—no sheltered intermediate space, but visitors entered immediately from the open air into the vestibule.

"It would be tame language," says Mr. E., "to speak of the present entrance (merely) as an improvement. Nothing can be in better taste than the porch with its lofty doors, its pointed arches, its ogee-shaped canopies with finials, and the cloister-like entrance." "The porch, entrance-passage, guard-room and gallery, were all designed by Sir John Thoroton from portions of Lincoln cathedral. The entrance-passage is lighted by eight windows (four on each side), between which shafts rising from flowered corbels, form the support of moulded ribs on the vaulted roof."

Judging from the plans, we should imagine there must be a striking degree of effect in the view through the arch facing the entrance, into what is called the Guard-room Gallery, formed by a screen of arches on a higher level, it being in fact the first landing, off from which lies the grand staircase. For want, however, of more exact explanation, and of either view or section, it is difficult to comprehend so clearly as we could wish to do, what, owing to the difference of levels, is rather a complex and intricate part of the interior. We may, therefore, express our regret that none of our graphic "Illustrators" and view-makers, should have thought proper to satisfy our curiosity relative to Belvoir. The most that any of them, we believe, have done, is to give us one or two general views of the Castle, but from such points as rather to exhibit its locality, the general character of the structure, and the various masses of building composing it—as seen rising above the lofty trees embosoming it—than to show what its architectural design really is. This is the case with the view (the north-east front), which serves as the frontispiece to the present volume. Greatly do we desiderate a distinct architectural view of the entrance and corridor connecting it with the building; as likewise of another representing that portion of the south-west front which forms the exterior of the chapel, and which is spoken of as being of "purely perpendicular character."

"It has some good features about it," continues the writer, "especially in the parapet above the arcade in the basement story, which formed no part of the original design by Wyatt, but was added by Sir John Thoroton, in imitation of a portion of the parapet in Lincoln Cathedral. The windows are of elegant proportions, and harmonize well with the general character and intention of the building. We might, perhaps, have wished that the embattled parapet of the two towers had been of a rather less gossamer character, and that more substantiality had been imparted to the pinnacles. But, upon the whole, the architecture of the chapel forms an exquisite break upon the general plainness of this part of the Castle. It comes upon the view so unexpectedly, and contrasts as effectually with the remainder of this front, as the little cultivated spots which we meet with in the surrounding scenery, when, after passing through the dense foliage of gigantic trees, we suddenly arrive at an open area, where the tasteful skill of the floriculturist has been at work."

We return again to the interior; but, referring to the work itself for descriptions of the several apartments, and of the paintings and other works of art they contain, shall merely enumerate some of the principal rooms, adding their respective dimensions. From the upper landing of the grand staircase, any of the following rooms may be immediately entered. The Picture Gallery (over the Guard-room gallery, and the ascent to it), the Regent's rooms (over the Guard-room or Vestibule), the Regent's gallery, an Ante or Waiting-room, beyond which is the principal library.

Picture Gallery 61.10′×25.8′ and 31.5′ high, lighted from above by a series of windows fitted with ground glass.

Regent's Rooms.—Sitting-room 24.6′×20.9′.
Bed-room 24.6′×18.
Dressing-room 21×17.9′.

Regent's Gallery, 131×17.8′, or, including the semi-circular bay, (35.9′ in diameter, and containing five windows) 35.8′. Height 18.2′. The folding doors at the S. W. end open into the tribune of the chapel.

Ante-room, 30.4′×21.6′ with a single window towards the inner court, but lighted principally by a lantern in the ceiling.

Library, 47×23.9′ and 18 high; with four windows on the side towards the inner court.

Grand Corridor, extreme length including the staircase on that side of the building, 120×24. Though called a corridor, the proportions and dimensions of this thoroughfare room entitle it just as well to the name of Gallery; and it is in fact occasionally used as a ball-room.

Green or Assembling Room, 27×24, and 17.6′ high.

Chinese Rooms: Setting Room 29×22.
Bed Room 26×17.
Dressing-room 26×17.

Elizabeth Saloon, 55×36, and 20.10′ high.

Grand Dining-room, 55×31, and 19 high. Five recesses, viz. one at each end, and three on the side opposite the windows, with two fire-places between them.

Hunters' Dining Room, 21×17.

Family Dining Room, 34×21.

This last is one of the suite of private apartments in the S. E. front; above which is another suite, occupied by the late Duchess; the principal one, a boudoir, 22.4′×19.6′, exclusive of the oriel window, which adds 6·3′ more to the length of the room, and which commands a most delightful prospect, where "the eye, passing over the foliage on the terraces immediately below the Castle, is refreshed by a beautiful expanse of water, immediately beyond which is rising ground covered with plantations. The village of Woodthorp, in the valley, a little to the left, with the spire of its simple church, is sufficiently distinct to form a sweet feature in this scene of rural repose. At a more remote distance, the magnificent mansion of Mr. Gregory (at Harlaxton), forms a terminal point for the eye to rest upon near the horizon of the landscape."

Here we must take leave of Belvoir—not because little more remains to be spoken of, for we have not even mentioned one principal

* How the fire originated, could, it seems, never be discovered—probably because those who could have cleared up the mystery chose to keep their own counsel. For some piquant remarks on the subject of such "accidents," we may refer our readers to an article in the last No. of the Polytechnic Journal, entitled the British Museum and its Library," where the writer indulges in some pleasantry on the *pyrophobia*—the excessive horror of fires and candles exhibited by the managers of that national institution—which is such that it induces them to close the reading rooms very long before sunset, during several months in the year.

If not as a preventive against fire, at least as a means of checking its progress, we would suggest that in all very extensive residences, particularly where the entire pile consists of distinct masses and parts, there should be exceedingly thick internal party walls between the different ranges of rooms, so that the fire could not spread beyond that portion of the plan where it might happen to break out. Were this done, not only would there be comparatively little danger, but also less alarm and confusion in case of fire, as the inmates would feel themselves in safety in other parts of the building.

† This gentleman, who was rector of Bottesford, adjoining Belvoir, from 1782 to 1820, (in which year he died at Belvoir Castle, Dec. 18th, in his 62nd year,) and who was knighted by George IV. when Regent, deserves to rank high among those who have cultivated the study of architecture. "One half of the present Castle," says Mr. Eller, "and certainly *the most beautiful portion* in an architectural point of view, was erected chiefly from his designs and under his superintendence."

object of attraction to visitors, namely the Mausoleum, of which, and also of Bottesford Church and its monuments, long descriptions are here given;—but we do so because we have already bestowed as much notice on Mr. Eller's book as our limits will permit. It has afforded us considerable gratification, and we would suggest, for his consideration, whether it would not be desirable to republish the description of the castle, &c., separately in a duodecimo volume, omitting altogether the biographical notices of artists in the account of the pictures; which being done, there would be opportunity for entering into some particulars that are now either passed over or but slightly touched upon. It would be a further improvement were the terraces to be shown in the ground floor plan of the building.

Graphic Illustrations with Historical and Descriptive Accounts of Toddington, Gloucestershire, the seat of Lord Sudeley. By JOHN BRITTON, F.S.A. Publisher, the Author, 1840.

By this work, containing twenty-three external and internal views, and nine lithographed plates of details, Mr. Britton has sought to make known to the public one of those modern adaptations of the pointed style to private dwelling houses, the excellence of which he has by his earlier works so mainly assisted to bring about. The energy with which Mr. Britton for more than five and forty years, has continued to superintend the illustration of our ancient buildings, and to direct public attention to their beauties, affords an example well worthy of imitation, and must entitle him to the warm applause of the right minded.

Lord Sudeley, the owner and the designer of the new mansion at Toddington, formed one of the Committee (as Mr. Hanbury Tracy,*) appointed to select from the numerous designs sent in competition for the new Houses of Parliament, and devoted much time and zeal to the investigation. The building under consideration which has occupied his Lordship's attention more than twenty years, proves fully that he was well qualified for the task, having an intimate knowledge of architecture as a fine art. The construction of a modern mansion in the style of buildings of the middle ages is not an undertaking of trifling difficulty. "By a judicious attention to appropriate models," says Mr. Willson in his preface to Pugin's specimens, "a modern residence of whatever size, may be constructed in the Gothic style without departing from sound principles of taste. Some modifications of ancient precedents must be allowed, for an absolute fidelity will frequently prove incompatible with convenience; but as few deviations as possible should be gone into; and above all, nothing should be attempted which is inconsistent with the character and situation of the place, or which cannot be executed on a proper scale of dimensions." This feeling is evident throughout Toddington, and has led to a very successful result, redounding to the credit of its designer the more highly because of the difficulty. Attached to the account of the house is a short essay on the comparative merits and eligibility of the Grecian, Roman, and Monastic or Gothic architecture for the purposes of the modern English mansion, wherein the author traces lightly the progress of architecture in England, and refers to those men who have chiefly aided this progress. In this essay Mr. Britton observes, "of the manner in which architects were employed soon after the Reformation, the household accounts of Henry VIII. furnish some curious but deplorable information. From these it appears that painters, sculptors, carvers, and *architects*, were retained at stipulated periodical wages. Holbein, John of Padua, Lawrence Bradshaw, Richard Lea, and some others were thus engaged; and they designed several of the mansions which were then erected, and which are now more admired in the picturesque drawings and engravings of the artist, than as comfortable residences for the noble or wealthy families of this age. So the châteaux of the old noblesse of France, and the castles of the Edwardian dynasties of England, are picturesque and imposing objects in the landscape, but have few charms or attractions to render them endurable as permanent homes for persons who wish to enjoy domestic quietude and comfort."

For Walpole's advocacy of Gothic architecture, although ill exemplified by him at Strawberry Hill, Mr. Britton gives his tribute of praise, and then describes some few of the better sort of dwellings more recently erected in England in this style.

Want of space however prevents us at this moment saying anything more of the work in question, than that it is a very valuable and acceptable addition to the scanty stock of books which we at present possess on domestic architecture.

* Mr. Tracy was raised to the peerage July 12, 1838.

Illustrations of Windsor Castle. By the late Sir JEFFRY WYATVILLE, R.A. London: Weale, 1841.

This is a folio work in two volumes, on a scale of magnificence but rarely seen, the size of the plates corresponding to the beauty of their execution. These plates are six and twenty in number, besides wood engravings, some of them too containing more than one view, and embracing nearly every part of the external architecture of the Castle and Stables, besides plans of the Castle in its former state. These engravings are executed in a manner so costly as only the devotion of an architect to his favourite subject could authorize, being quite beyond the usual limits of publishing enterprize. The letterpress being printed on paper of the same dimensions, makes the volume rather unwieldly as a readable book, which is to be regretted as the valuable matter contained in its pages is such as to excite great interest. The general superintendence has been confided to Mr. Henry Ashton, and the literary portion by him again transferred to Mr. Poynter, than whom few could be found better qualified. The editors having determined upon excluding a description of the interior of the edifice on account of so much of its decoration being not merely of a passing interest, but adopted against the will of the architect, necessarily restricted themselves to a mere antiquarian description of the Castle. To this task Mr. Poynter has brought a depth of research, which has added much that is new to our previous knowledge of the subject, and given a degree of certainty to many points which before were involved in obscurity. The result of these labours may not be great, but the extent of research required is easily to be appreciated. To transfer to our pages any thing like a complete history of the Castle would be of course impossible, but we cannot allow this volume to pass us without gleaning in some way from its pages.

In the reign of Edward the Third, called the Confessor, we find the earliest authentic notice of Windsor, when it was granted by that last reigning sovereign of the Saxon kingly race to the Abbey of Westminster, under the name of Wyndleshore, a grant which by William the Norman was resumed by an exchange for some lands in Essex. This prince erected a castle at Windsor, which is registered in Domesday Book. At Old Windsor, however, the Saxon kings are believed to have had a palace at an early period. In the reign of Henry III., the castle was rebuilt, and from this period begins to date its historical renown, being in the next reign considered second in importance only to the Tower of London. A few architectural fragments brought to light during the progress of the improvements, are supposed to be the only relics of this edifice. Henry III. made great improvements in the lower ward, and the traces of his work are to be recognized in the present day, during the whole of his reign indeed extensive buildings were in progress. Of the chapel built by this prince, Mr. Poynter is of opinion that a doorway may be recognized behind the altar of St. Georges. In two years the large sum of 873*l*. was allotted to the works. The Belltower the editor attributes to the 25th year of Henry's reign, and to the Garter Tower he is inclined to assign the same date. It is to be observed that during this reign we find frequent provision for chimneys and glass windows; it seems also that the erection of temporary wooden dwellings within the Castle was not uncommon. In searching out the particulars of the works of Henry III., Mr. Poynter has made a very diligent investigation of the Pope and Close Rolls and other records, which have enabled him to employ a minuteness of description equally interesting to the antiquarian and to the architect. Of how much value researches of this nature may become we see when we come to consider how they bear upon any restoration of the western extremity of the Castle.

The next great epoch in the history of the Castle is the reign of Edward III., a period respecting which we have ample information. The foundation of the College and restoration of St. George's Chapel was the first step taken by this monarch, which was succeeded by the inauguration of the Order of the Garter. In 1356, the celebrated William of Wykeham was appointed surveyor, and the works proceeded with great vigour, and in 1359 three hundred and sixty masons were pressed for the service of the castle, and in 1362 on account of a pestilence three hundred and two more. In the first half of 1363 as much as 3802*l*. 17*s*. 8*d*. was paid for the works including 932*l*. for lead, and thirty-six glaziers were impressed, twenty-four to serve in London, and twelve at Windsor. More masons were also impressed. In 1364 the whole expenditure was 3031*l*. 9*s*. 9*d*. In 1365 a payment occurs of 13*l*. 6*s*. 8*d*. to John, a canon of St. Catharine's, the king's picture painter, for a picture with images for the chapel, and another of 50*l*. to John de Lyndesay, for a table with figures also for the chapel. It is to be remarked that then as during the reign of Henry III., the artists appear to have been generally ecclesiastics, dignitaries of the church combining the practice of the arts with their clerical functions. In 1366, 600*l*. was paid for lead, and the whole expenditure was 4076*l*.

9s. 9d. To William de Burdon, the king's painter, was paid 13l. 7s. for a great tablet for the altar. In each of the years 1367 and 1368, the expenditure was about 2000l. To William de Burdon was paid 20l. more for his picture for the chapel, 10l. was paid for buying marble, 60l. for German copper for bells, and the very large sum of 200l. for a great alabaster table for the high altar of St. George's. This according to the largest estimate would be 6000l. of the present money. After 1369 no more workmen were impressed, and in a few years the expenditure was gradually diminished; the last payment being in 1374. In this reign from a payment of 50l. for a new bell for it, a clock seems to have been placed in the bell-tower, as has been the practice down to the present day. Of the early works of Edward III. a portion is the Dean's cloister, of other works the outlines are scarcely to be traced, although he added to the castle the upper ward. Here however is yet to be seen the principal gate adjoining the keep. In the interior of the castle the work of Edward III. is still visible in the vaulted basement of the Devil Tower. The arches of this vaulting are four centered, and present an early specimen of the systematic use of that form. By Edward III. most of the buildings of Henry I. were pulled down, and the Keep is supposed to have been rebuilt.

Under Richard II. in 1390, the appointment of Clerk of the Works was for a short time held by Geffrey Chaucer, the Father of Modern English Poetry, his salary being 2s. a day, with the power of appointing a deputy. Under Henry VI. the revenues of Windsor amounted to 207l. 17s. 5½d., a sum far from sufficient to meet the expenses; the manors of Cookham, Bray, Binfield and Sunninghill were further charged with 100 marks per annum for the repairs.

By Edward IV. the existing Collegiate Chapel of St. George was built, the direction of the works being confided to Richard Beauchamp, Bishop of Salisbury, a most distinguished prelate and architect. In 1480 the expenditure was 1408l. 16s. 9½d. The principal part of the stone came from Tainton in Oxfordshire, where Henry Jennings the master mason purchased 9755 feet at 2d. per foot; the carriage by land through Burford and Culham to Henley cost 151l. 12s., and it was thence conveyed by water to Windsor bridge. Some portion of Caen stone was also used, and Heath stone from Cranbourne Chase. The timber came principally from Upton, Ashridge, Farnham, Wyke and Sunninghill, and the carriage of these materials and of sand and lime amounted to 29l. 10s. 3½d. The cost of scaffolding and other plant, tools, smith's bellows, tiles and tilepins for workmen's sheds, withes to tie scaffolding, straw, candles, seacoal, charcoal, steel, iron for the windows, iron bolts for the carts, sheet iron, tin, tin pans, nails, &c. amounted to 141l. 8s. 1d., and the workmen's wages to 555l. 6s. 1½d. For these works masons were impressed, and the best workmen were so monopolized by the king for St. George's, that other works were sadly impeded, as was the case with the Divinity School at Oxford. Carving seems now to have become a secular employment, and a large sum was appropriated for this class of work, being in this year 75l. 4s. 6d. With the Chapel the Chapter House was also rebuilt. In 1481 stone was obtained from Caen, Tainton, Sherborne, Ryegate, Milton and Little Daryngton, and the expenditure for the year 1249l. 18s. 5d., being for stone 137l. 5s., for carriage 349l. 18s. 0½d., for other materials and stores 144l. 11s. 11½d., and for wages 457l. 10s. 6½d., including 62l. 12s. 6d. for carving. The next year the expenditure was 1145l. 7s. 2½d., of which for carving 100l. 10s. 4d.; and in 1483 960l. 12s. 10d., of which 186l. 10s. 4d. for carving. Thus in four years out of a total expenditure of 4674l. 15s. 3d., 425l. 7s. 8d. was paid for wood carving. In 1483 Edward IV. was buried here, behind a curious screen of iron work, an elaborate piece of workmanship, generally thought to be of foreign manufacture, but by the editor assigned to John Tresilian, the master smith. Among the benefactions of Bishop Beauchamp to the Chapel, was the following exertion of the influence in its favour. John Shorne or Schorne was a pious rector of Northmarston in Bucks, about the year 1290, and held in great veneration for the virtues which his benediction had imparted to a holy well in his parish, and for his miracles, one of which, the feat of conjuring the devil into a boot, was considered so remarkable, that it was represented in the east window of his church. Bishop Beauchamp obtained a license from the Pope to remove the shrine of John Shorne from Northmarston wherever he pleased, and he accordingly removed it to the Lincoln Chapel at Windsor. At the Reformation, the College of St. George's lost 500l. per annum from the offerings at this shrine. In 1481 Bishop Beauchamp was succeeded by Sir Reginald Bray. Richard III., the last of the Plantagenets, during the first year of his reign appropriated 733l. 10s. 9¾d. for the building of the College and Chapel. In 1484 the body of Henry VI. was removed from Chertsey and buried in the Chapel.

Henry VII. left his personal property and the profits of his lands for the completion of the new works in the body of the Chapel. During his reign the works were directed by Sir Reginald Bray, who built the Bray Chapel, now the South Transept. In 1508 the roof of the Choir was constructed in stone, the expense being supplied by a subscription of the Knights of the Garter. The main vaulting is by the editor cited as without exception the most beautiful specimen of the Gothic stone roof in existence. Henry VII. took down the original chapel of Henry III., for the purpose of building a royal mausoleum in its room, but the work was not completed. The shell of the building is supposed to be of his reign. In 1500 the Deanery was rebuilt by Doctor Christopher Urswick; the houses of the Minor Canons are also attributed to this reign. A lofty oriel in the upper ward and the inclosure of the stairs to the Keep may be assigned to the same date. By a typographical error in the work before us, the death of Henry VII. is assigned to 1503 instead of 1509. The principal work of Henry VIII. was the great gateway of the lower ward of the Castle. In 1528 the exquisite fan groining of the roof at the interstices of the Cross of the Chapel was executed by subscription of the Order of the Garter. Wolsey began a stately tomb at Windsor in the chapel erected by Henry VII. hence named Wolsey's Tomb House. On this work he employed Benedetto, a Florentine artist, who began it in 1524, and to him were paid 4250 ducats, and 380l. 13s. for gilding. These works were destroyed by some of the Parliamentary troops in 1646 for the sake of the metal, except a sarcophagus of black marble of Italian design, which in 1805 was placed over the tomb of Nelson in the crypt of St. Paul's. In 1519 James Denton, one of the canons, founded the building called the New Commons, now incorporated with the Prebendal Houses, but of which a doorway is preserved, richly ornamented. Under Edward VI. in 1537, the fan vaultings of the side aisles to the choir were executed, and works begun for bringing a supply of water to the Castle from Blackmore Park near Winkfield, a distance of five miles. To supply the pipes; Wallingford Castle and other ancient buildings were stripped of their lead, 370 cwt. from Maidstone. Under Queen Mary in 1555 the pipe was brought up into the middle of the Upper Court of the Castle, "and there the water plenteously did rise 13 foot high." In this place was formed a reservoir from which every part of the Castle was supplied. In this reign the houses of the military knights were completed, having been begun in the third year of Philip and Mary, and finished in three years at an expense of 2747l. 7s. 6d. The Square Tower and some portion of the structure to the east were previously standing, and the additions and alterations were made with materials taken from other buildings. The stone was brought from Reading Abbey, and eighteen fothers of lead, and "twenty old apparails for chimneys," from Suffolk Place in Southwark. To Elizabeth Windsor Castle is indebted for its terrace, although some parts of it appear to have been in existence previously, every ten feet of the terrace wall, twenty feet in height, and six feet at the base gradually sloping to six feet at the top, costing 125l. 16s. 8d. In 1570 1900l. was expended on a thorough repair of the Chapel, supposed to be the private Chapel adjoining St. George's Hall. A general repair of the Castle was made by this Queen, which in the six years ending 1575 had amounted to 6600l. In 1576 Queen Elizabeth's Gallery was built, it now forms a portion of the Library. In the seven years ending 1577 the works had cost 7800l. In the report on the works in 1580, a clause, relating to the apartments of the Maids of Honour, recites that these ladies "desire to have their chamber ceiled, and the partition, that is of boards there, to be made higher, for that the servants look over." In this reign for the first time we have a connected description of the Castle by Paul Hentzner, a German traveller who visited England in 1598. He says that in the Castle he was shown among other things the horn of a unicorn, eight spans and a half in length, and valued at 10,000l.

Under James I. was executed the survey of the Parks and Forest by John Norden, which contains the first view of the Castle. By an entry in the Issue Roll for 1607, it appears that this survey was presented to the King by its author, who was rewarded with a gift of two hundred pounds. Nothing it is said was done at Windsor under Charles I. until 1635, when several alterations were made. It was the intention of Charles I. to convert the Tomb-house into a place of sepulture for his family, but this plan was not carried out. On the deposition of Charles I., Captain Fogg, an officer of the Parliament, and subsequently, Colonel Venn, under orders from the Commonwealth, carried off the plate and decorations of the Chapel and ruined the painted windows. In the reign of Oliver Cromwell many repairs were made, and the revenues of the Castle greatly improved. This prince also attached to the Chapel the foundation of the Military Knights, for whom Sir Francis Crane's building was erected. Under Charles II. a complete alteration of the Castle was made by Sir John Denham and Sir Christopher Wren, and the best artists were employed upon the paintings and carvings of the interior, in which a profusion of the exquisite works of Grinling Gibbon still exist. Charles's principal addition to the Castle was the Star Building, now called the Stuart Building, about one hundred and

seventy feet long. Verrio was employed on the allegorical paintings, for which he was to receive a sum of above seven thousand pounds in five years; in 1701, however, 20 years after, 1800*l*. was still due to him. In 1674 St. George's Hall was fitted up as a theatre, and French plays performed in it. In 1676 the North Terrace was enlarged to its present extent. Wren's alterations of the exterior of the Castle were far from improvements, for he left it with a most unpicturesque appearance which it retained for above a century. In 1680 the equestrian statue of Charles II. was erected by Tobias Rustat, Yeoman of the Robes. It is the work of Josias Ibach Strada of Bremen, but the sculptures on the pedestal are attributed to Grinling Gibbons. In this reign was commenced the Long Walk. James II. fitted up the Tomb House as a Catholic Chapel, which Verrio was employed in decorating. William III. contemplated great improvements, and employed Wren to draw a plan in the Italian style, which is inserted in the work under our consideration; nothing however was done. Under Queen Anne Sir James Thornhill was employed in painting the Great Staircase, and in the first eight years 40,000*l*. were laid out in repairs. The extraordinary works were principally confined to the Parks.

The two first Hanoverian kings merely kept the Castle in repair, George the 2nd however employed William Kent at an expense of 400*l*. in restoring some of the paintings. George III. erected the detached edifice opposite the South Terrace, called the Queen's Lodge, which was completed in 1782 at an expense of nearly 44,000*l*., and is said by the editor to have been executed from the plans of His Majesty, "whose taste for practical architecture is well known." It was removed in 1823 by George IV. In 1787 Mr. Emlyn was employed to restore the interior of St. George's Chapel, at the private expense of George III. In 1796 the painted glass window in the Chapel was completed by Jarvis and Forest, from the designs of West. In 1796 James Wyatt was appointed Surveyor General, who effected many improvements. In 1810 the design of establishing a royal sepulchre was carried into effect, and a vault constructed under the Tomb House. George IV. having decided upon extending the Castle as an imperial residence, obtained a preliminary grant of 300,000*l*. from parliament, and appointed Mr. Jeffry Wyatt to the superintendence of the works, who in 1828 received from the monarch the honour of knighthood, by the title of Sir Jeffry Wyatville. The cost of the whole of Sir Jeffry's works was 771,000*l*., and they included the following works, new, rebuilt, or thoroughly repaired, New St. George's Gate; New Octagon Turret to Devil Tower; York, Lancaster, Chester, Prince of Wales's, Brunswick, George III., and Round Towers; George IV. Gateway; a great length of walling; a new Turret to the Stuart Buildings; Grand Entrance Tower; Front of St. George's Hall; Kitchen Gateway; and two octagon Turrets; Gallery from the Devil Tower to St. George's Hall, 550 feet long, new terrace 1060 feet long, some part of the walls of which is 30 feet high, lowering the court-yard from three to six feet, removed 13,000 cubic yards. Internally:—His Majesty's apartments with a corridor 500 feet long, kitchen and servants apartments, state apartments, St. George's Hall; ball-room; Waterloo Gallery; grand staircase. In the Waterloo Gallery George IV. placed the series of portraits painted by Sir Thomas Lawrence. In the reconstruction of the Keep Sir Jeffry managed with great skill to sustain the increased weight of this enormous pile on an artificial rock of concrete. During the reign of William IV. and Queen Victoria, the works left unfinished by George IV. were successfully prosecuted by Sir Jeffry, until his death in 1840, when the task devolved upon Mr. Henry Ashton, by whom the new stables are being constructed at an expense of 70,000*l*.

As Windsor Castle has employed the talents of some of the most celebrated of our architects and artists, we thought that the following chronological account of officers and persons employed, drawn up by us from Mr. Poynter's materials would prove of interest to our readers.

1173. Master Geoffry, master of the works.

1179. Master Osbert, ditto.

1223. John le Draper and William, the clerk of Windsor, ditto, (Master Thomas, the king's carpenter).

1226. (Master Nicholas, the king's carpenter, allowance for a gown 15s., Master Jordan, ditto).

1228. William de Millars, constable of the castle.

1237. William de Burgh, director of the works.

1240-62. (Friar William of Westminster, a painter, and John Sot his assistant).

1241. (Master Simon, king's carpenter).

1260. (Master John of Gloster, king's mason).

1261. Richard de Fremantle, Custos of the manor of Cookham and Bray.

1350. (John de Spaulee, master of the stonehewers).

1351. James de Dorchester, deputy constable of the Castle.

1356. William de Wykeham, surveyor, (Bishop of Winchester), salary a shilling a day, a shilling extra while travelling, and three shillings per week for his clerk. He succeeded Robert de Bernham and Richard de Rochelf who had the same salary. In 1357 Wykeham obtained an increase of a shilling a day.

1363. William de Mulso, canon of Windsor, surveyor.

1366. (John, canon of St. Katharine's, king's painter; John or William de Lyndesay, of London, wood carver).

1387. Adam de Hertyngdon, canon of Windsor, surveyor or clerk of the works; (William de Burdon, king's painter).

1390. Geffrey Chaucer, clerk of the works, salary two shillings a day, with privilege of appointing deputy.

1391. Unknown.

1474. Richard Beauchamp, Bishop of Salisbury, surveyor of the works. (Henry Jennings, master mason; Thomas Canceler, clerk of the works, salary 10*l*.; John Tresilian, master smith, 1*s*. 4*d*. per day. The clerk of the works, master mason and master carpenter had gowns allowed them. Robert Ellis, John Filles, Derrick Van Grove and Giles Van Castel, carvers.)

1481. Sir Reginald Bray, surveyor of the works.

1505. (John Hylmer and William Vertue, contractors for the stone work of the roof of St. George's Chapel).

1524. (Benedetto, artist, employed on Wolsey's tomb).

1575. Humphrey Mulhill, clerk of the works; ditto, comptroller, 2*s*. per day; Henry Hawthorne, clerk of the works, 2*s*. per day.

1603. Sir John Norris, comptroller; Sir John Trevor, surveyor of the works.

1637. Sir Robert Bennet, surveyor of the works; (David Ramsay, Esq., king's clockmaker).

1639. (Christopher Van Viasen of Nuremburg, makes the plate for the Chapel).

1660. Sir John Denham, surveyor-general; Sir Christopher Wren, deputy.

16—. Sir Christopher Wren, surveyor-general; Baptist May, clerk of the works.

1676. (Antonio Verrio, painter; Grinling Gibbons, carver).

1679. (Josias Ibach Strada, casts statue of Charles II).

1707. (Henry Wise, landscape gardener).

1710. (Sir James Thornhill, painter).

1746. (William Kent, painter).

1778. George III. builds Queen's Lodge after his own designs.

1787. Mr. Emlyn restores part of St. George's Chapel.

1795. (Benjamin West, painter; Jarvis and Forest, painters on glass).

1796. James Wyatt, surveyor-general.

1815. (Sir Thomas Lawrence, painter).

1824. Sir Jeffry Wyatville, surveyor-general; (Sir Richard Westmacott, sculptor).

1840. Henry Ashton, architect.

The description of the plates is far from being so copious as we could wish, being confined principally to an account of the alterations made by Sir Jeffry Wyatville; but it is but fair that we should mention that Mr. Poynter is not responsible for this portion of the work. It is mentioned in describing the Round Tower, that Sir Jeffry being unwilling to disturb the associations of the spot, has provided holes in the stonework of the Castle for the jackdaws and starlings who build here in numbers, to form their nests in. They are for the most part invisible from below, except between the corbels of the battlements of the Keep. From the level of the road on the west side, to the top of the flags left of the Keep, is a total height of 208 feet, of which the Flag Tower is 25 feet, and the flag staff 50 feet; the diameter of the Keep is 102 feet.

On the Nature, Properties, and Applications of Steam, and on Steam Navigation. From the seventh edition of the Encyclopædia Britannica. By John Scott Russell, M.A., F.R.S.E. Edinburgh: Adam and Charles Black.

The volume before us comprises, in addition to the articles on the above subjects which are printed in the Encyclopædia, an historical account of the origin and progress of the art of steam navigation down to the year 1839, by the same author; besides the account of the locomotive steam-engine, from the Treatise on Railways by Lieutenant Lecount.

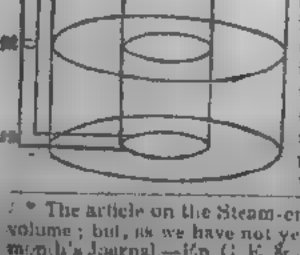
The present articles, STEAM and STEAM-ENGINE, in the Encyclopædia Britannica, are intended to contain all that was interesting and valuable in the original articles (written by Dr. Robison,) with Mr. Watt's notes, enriched by the results of subsequent labour and research; and it has been the author's aim, as he states in the preface to the present volume, "to add to all that Robison had originally said of

Watt's invention, what he would have required to add if he had lived to witness its present extended use, its multifarious applications, its varied forms, its modifications in material and construction* He has endeavoured to place before the reader, in a simple form, all the most important information which many years of research and of practical experience in a favourite subject have placed in his possession; and "the reader who is familiar with the subject will," he says, "readily discover that he has read and thought for himself, and that his errors, if many, are at least his own. In one point he trusts he has facilitated the progress of the student. While giving the general reasoning of complex calculations, he has endeavoured to disembarrass them as much as possible of that parade of calculus which exhibits the author at the expense of the reader; and rather to present their results in that simple form in which alone great truths present themselves to those who thoroughly understand them."

The plan of the work here laid down is in accordance with the nature of an Encyclopædia, which, being a work of a popular character, and a book of reference rather than instruction, many, if not the majority of its readers, moreover, being uninitiated in the arcana of abstruse mathematical science, and therefore willing to take for granted the truth of propositions, the demonstration of which they are unable to comprehend, should not be unnecessarily encumbered with complex and difficult calculations. It should, however, at the same time be borne in mind that some, and we trust we may say many, of the readers of the Encyclopædia are possessed of sufficient scientific knowledge to enable them to think and judge for themselves. Therefore, although the facts advanced should in general be such as are recognized by the best acknowledged authorities, and in support of which it suffices in most cases to cite the authority, yet, when any *new* proposition is enunciated, or any new doctrine propounded, it should be accompanied by a rigorous demonstration, or it must incur the risk of being rejected as unfounded. There are two instances in the work under review, in which we do not find the reasoning adequate to justify the conclusion; we allude to the determination of the *best vacuum* in the condenser of a steam engine, page 276, and of the best proportion of power to tonnage in sea-going vessels, page 288. We must, however, remark, in justice to the author, that we have seldom, if ever, met with a work so full of typographical errors, by which so much unnecessary labour is imposed on the reader, that many are deterred from attempting to make themselves masters of the author's meaning, and which are in some cases so serious as perhaps even to render the accomplishment of the task impossible. Some of the errors are of such a nature that it is difficult to decide whether they are to be ascribed to the author or to the printer.

The article Steam, which occupies nearly the first half of the volume is on the whole a valuable contribution, particularly the second section, in which are collected together all the most recent experimental researches concerning the elastic force of steam at different temperatures, as well as the most esteemed of the earlier experiments, accompanied by figures of the apparatus employed.

In the first section, where the properties, phenomena, and application of steam are considered in a general manner, there is the following simple illustration of the doctrine of latent heat by Dr. Dalton, from which those who are not familiar with the operations of heat may form a tolerably correct notion of the phenomenon in question:



The liquid and its vapour may be considered as two reservoirs of caloric, capable of holding different quantities of that fluid. Let figure 1 represent to us such an arrangement; the internal cylinder of smaller capacity, the external one of enlarged capacity surrounding and extending far above it, and a small open tube of glass, communicating freely at the bottom with the internal cylinder. Let us now conceive water to be poured into the internal cylinder, the water will manifestly flow into the slender tube till it stand on the same level in the tube as in the cylinder. If any additional quantity be now poured into the internal cylinder, the rise of water in the slender glass tube will serve as an index of the quantity of added fluid; and when it is filled to the top, the fluid will stand at the height marked 212°, and will still be a correct index of the addition of fluid. But if more water be now added to it, it will not make its appearance in the slender tube, but will simply overflow from the internal cylinder over into that of enlarged capacity, so that, while a large quantity is passing into the vessel and gradually filling it up to 212°, no additional rise takes place until the whole of the outer cylinder becomes filled to that point, after which any further addition will again become sensible, by a corresponding rise in the tube. This process is in precise analogy to the succession of circumstances in heating a liquid, and converting it into steam. The internal cylinder represents the liquid, the external one the vapour of greater capacity, and the slender glass tube at the side the thermometer placed in communication with them. When heat flows into the liquid, it passes equally into the thermometer; and each increment of the one produces an equal increment in the other, until the liquid reaches the limit of its capacity, when it suddenly begins to enlarge its bulk and take the form of steam; but the quantity of heat required to fill up this enlarged capacity is so great, as to require about 5½ times as much to fill it as was contained in the whole liquid before, so that all this time the thermometer is standing still, and it is not until the whole of the steam is thus supplied with 212° of caloric, that the thermometer will begin to show any further elevation; after which, any increment of heat thrown into the steam will make its appearance on the thermometer, and proceed as formerly, by simultaneous increments.

As a practical application of the influence of pressure on the boiling point of water, the following rule is given for finding the heights of mountains by boiling water:

Boil pure water in an open vessel at the bottom of the elevation, and observe on the thermometer the point at which it boils. Boil it again at the top of the mountain, and observe with the thermometer the point at which it now boils: the difference of temperature, multiplied by 530 feet, will give a close approximation to the height of the upper above the lower station.

This will give an approximation; but, if greater accuracy be required, it will further be necessary to correct for the difference of the temperature of the air at the two stations, in the following manner. Add the temperatures of the air at the stations, and subtract 64 from their sum, multiply the remainder by one thousandth part of the height found; and this will be the correction to be added to the height formerly found. The result thus found will still require a slight correction for the figure of the earth and latitude of the place; but this does not amount to more in our latitude than an addition of about two feet in a thousand, which forms a second correction.

To illustrate the mode of deducing heights from the boiling point, as we have given it, we take the following example.

Water boils on the top of Ben Nevis at 203·8°, while at the side of the Caledonian Canal it boils at 212°, the temperature being 30° on the summit of the mountain, and 35° below. In order to determine the height,

From 212°	
Take 203·8°	To 30°
	Add 35°
There remains 8·2°	
Multiply by 530	Sum 65°
	Subt. 64°
246·0	
410	Remain 1° mult. by 4·346
4346 first approx.	Latitude 56° nearly
4 first correct.	Mult. 4·350
	by 2·
4350 second approx.	
8·7 second correct.	8·700

Calc. height, 4358·7 third approximation.
4358· true measured height—the difference being less than 1 foot.

This method, however, is seldom susceptible of so high a degree of accuracy, even with the most carefully conducted experiments.

There is also a description with explanatory figures, of the elegant and compact apparatus contrived by the Rev. F. J. H. Wollaston for facilitating the procedure of taking the observations with the requisite precision.

Among the contents of the second section we may mention, as particularly worthy of notice, the abridged account of the experiments undertaken by the French Academy of Sciences, and conducted principally by the M. M. Arago and Dulong, having for its object the discovery of the relation existing between the temperature and elastic force of steam; and those conducted, with the same object, by the committee of the Franklin Institute of Pennsylvania, appointed to examine into the causes of the explosions of the boilers used on board of steam-boats, and to devise the most effectual means of preventing the accidents, or of diminishing the extent of their injurious effects. The former were completed in 1829, and are in every respect entitled to a larger share of confidence than the latter, as well on account of the greater perfection of the apparatus employed and the extraordinary care bestowed upon the manipulations, as the names of two philosophers so well versed in experiments of a similar nature.

In the 3rd section, *on the mathematical law which connects the elastic force of vapour with its temperature*, Mr. Russel has certainly laid before his readers a considerable collection of formulæ (15 in number)

* The article on the Steam-engine is, we believe, published in a separate volume; but, as we have not yet seen it, we are unable to notice it in this month's Journal.—Ed. C. E. & A. Journal.

previously proposed by divers authors to represent that law, none of which are applicable but in a limited extent of the scale; but we are surprised to find that he has made no mention of that proposed by Mr. A. A. Mornay in the second volume of our Journal, page 200, which represents Dalton's experiments below 212°, and those of the French Academy up to 24 atmospheres, (beyond which they did not extend) within 2·45 degrees Fahr. at the latter limit, where a new formula, proposed by the author of the present work, gives a difference of 10·26 degrees.

In the reasoning through which he arrives at this formula, we rather suspect that Mr. Russell has fallen into the error he deprecates so much in his preface—that of *exhibiting the author at the expense of the reader*, though we think his *parade of calculus* only calculated to dazzle the *very* ignorant, without being intelligible to the mathematician. What, for instance, do the series α, β, γ, and the equations δ, ϵ, (page 113) signify? We confess they are above our comprehension, but perhaps some more profound mathematician might be able to explain their meaning, and to point out their connexion with the laws of temperature and pressure, mentioned in the previous part of the paragraph, and with each other. By some means, however, we are led to the equation, (page 116)

$$\frac{t+121^\circ}{333^\circ} = (1·11401)^{\frac{\log F}{\log 2}} \quad . \quad . \quad . \quad T$$

which appears in an entirely different form from any other that has been published, but which differs in fact from Tredgold's *only* in the values of the constants; it is, indeed, when freed from logarithms, nothing more or less than the following:

$$F = \left(\frac{t+121}{333}\right)^{6·42}.$$

Mr. Mornay's formula alluded to above, possesses this great advantage over the others, that it furnishes a very simple equation for finding the elastic force of steam in terms of its density alone, which is necessary in calculating the effect of steam used expansively in steam engines. Regarding the density of steam Mr. Russell has given no calculations at all, although, besides the formula just alluded to, one has been proposed by Mr. Navier, and a modification of it employed by the Count de Pambour in his *Theory of the Steam Engine*, published in 1839; but there is in the 4th section a very comprehensive table of the density of steam at different temperatures, by Gay-Lussac, as well as an engraving and description of the simple and elegant apparatus used by that philosopher, with his method of operating.

The 5th section, *on the application of our knowledge of the properties, phenomena, and laws of steam to practical and economical purposes*, is interesting as far as it goes; but, as we stated at the beginning of this notice, the most important application, the Steam Engine, is published in a separate volume.

The article STEAM NAVIGATION might, with greater propriety, be entitled "the Steam Navigation of Scotland and the United States," the share of that part of Great Britain called England being represented by the following paragraph:

"To the talent of Mr. Maudslay of London, the present marine engine owes the introduction of that high degree of precision in its construction and details, which gives it so much durability and efficacy as a machine."

From the tenor of this article it would appear that the author was utterly ignorant of the numerous steam boats with which the river Thames is studded at all hours of the day, and some of which vie in speed with the vaunted American steam boats, and that he knew of no steam vessels which navigate the ocean with other than Scotch engines. He does not say (is he ignorant of the fact?) that the Great Western, with Maudslay's engines, makes better passages to New York than the British Queen, with Napier's. The history of the progress and present condition of the art, as here traced, thus bears reference only to the two countries named above—Scotland and the United States; it is, however, as such, interesting enough, but would be rendered much more so, if combined with the history of the art in England.

The following paragraph in page 268, taken in conjunction with the omission of all mention of Maudslay's four cylinder engine, and with the description of Humphreys' trunk-engine, accompanied by a wood cut, in the preceding page, would corroborate the opinion that the author had but a very limited knowledge of the state of Steam Navigation in England.

For a like purpose, oscillating cylinders have been used with some measure of success. Rotatory engines have been unsuccessfully tried. The reader may now examine the vertical engines in the plates.

We believe the only trunk-engine yet made is that of the Dartford, which turned out a failure, while many steam boats now running on the Thames are fitted with oscillating engines, among which are some of the swiftest boats on the river.

We copy the following proof of the doctrine that *the vacuum in a condenser may be too good*, or rather that any improvement in the vacuum beyond a certain limit must be obtained at the expense of more fuel than it is worth; because it is not altogether without foundation, but, by reason of false notation, seems a tissue of absurdity and contradiction.

Let t = the caloric of water of 1°.
c = the constituent caloric of water in the state of steam.
e = the total force of steam in the boiler in inches of mercury;
and x = the elastic force of steam at the temperature of best condensation which we seek to discover.

Then from the law which connects the elastic force of steam with temperature, as already determined in our treatise on Steam, it follows, that in the case of maximum effect, or the temperature of best condensation,

$$\frac{t}{c} = \frac{x}{e} \text{ that is } x = \frac{e\,t}{c}$$

now c = 1000, and if the steam in the boiler be at 5 lb. above the atmosphere, or if e = 40 inches of mercury, and t = 1.

$$x = \frac{40}{1000} = 0·04$$

Again, if the steam be at 7½ lb. = 45 inches,

$$x = \frac{45}{1000} = 0·045$$

Again, if the steam be at 10 lb. = 50 inches,

$$x = \frac{50}{1000} = 0·05$$

Hence, we find that the best elasticity or temperature in the condenser depends on the elastic force of the steam in the boiler.

With steam of 5 lb. in the boiler, the elasticity of maximum effect in the condenser is at 93° of Fahrenheit, and the best vacuum in the barometer is 28. With steam of 7½ lb. in the boiler, the elasticity of maximum effect in the condenser is 95° of Fahrenheit, and the best vacuum in the barometer is 27·8. With steam of 10 lb. in the boiler, the elasticity of maximum effect in the condenser is 97°, and the best vacuum in the barometer is 27·5. In like manner it would be found that with steam of 50 lb. in the boiler, worked expansively, as in Cornwall, the best vacuum in the condenser would be about 26° on the barometer.

Our first impression on reading this proof was that it was altogether fallacious, and, as the calculation was not supported by reasoning, it was not likely to convince us of the contrary; but, on consideration, it seeming probable that the general proposition was true, although Mr. Russell's equation was not the interpretation of a truth, we investigated the subject more closely, and found that this equation did not represent the author's own opinion, but that x ought to stand for the increment of elastic force due to the increment t of heat at the temperature of most advantageous condensation, that c ought to represent the total quantity of caloric required to evaporate water from that temperature, and not merely the amount of latent heat at 212°, and that e should express, not the total pressure in the boiler, but the mean effective pressure on the piston before the allowance for friction has been deducted. The equation should therefore stand thus, retaining x with the signification first assigned to it by Mr. Russell, and expressing by *dif.* x a very small difference of elastic force, and by *dif.* t the corresponding very small difference of temperature,

$$\frac{dif.\ x}{e} = \frac{dif.\ t}{c};$$

the explanation of which is as follows:

The first member expresses the ratio of an assumed small gain of power to the total power exerted by the steam, and the second member the ratio of the quantity of heat thereby abstracted from the feed water (which must be restored in the boiler at the expense of a proportionate quantity of fuel) to the total amount of heat requisite to convert it into steam, or, which is the same thing, the ratio of the extra fuel to the total quantity used. Now it is obvious that, if these two ratios are equal, that is, if the increase of power is in proportion to the increase in the consumption of fuel, there is no gain of duty, and, of course, if the second member were greater than the first, the result would be a diminution of duty.

If we make the small difference of temperature = 1°, as Mr. Russell has done, *dif.* x will express the increment of force due to an increment of 1° of temperature; and, if we suppose the best temperature

of condensation to be 100°, we shall have $c = 112 + 1000 = 1112$, and the above equation may be put in the form,

$$dif.\ x = \frac{e}{1112}.$$

If the pressure in the boiler be about 5 lb. above the atmosphere, we shall not have a greater mean pressure than about 30 inches in the cylinder, in which case

$$dif.\ x = \frac{30}{1112} = 0{\cdot}027.$$

This is about the difference between the elastic force of steam at 72 and 73 degrees, according to Dr. Dalton's latest experiments, and the force at 73° is 0·95 inch; so that, when the mean pressure in the cylinder is 30 inches, and the barometer without stands at 29½ inches, the condenser barometer should mark 28·55 inches.

The calculation of the best proportion of power to tonnage (page 268) is so confused by errors (of the press?), that we have no leisure at present to wade through it.

The article on *the immediate Mechanism of Propulsion* is defective in as much as the Archimedean Screw Propeller is not so much as mentioned, and the author seems to have formed an erroneous idea of the principle of Morgan's Paddle Wheel, in consequence of a trifling resemblance which it bears to Oldham's Wheel. See the article *On Paddle Wheels* in the Appendix to the new edition of "Tredgold on the Steam Engine."

The Historical Sketch of Steam Locomotion, by Lieut. Lecount, forms an interesting appendix to the work, which on the whole contains much useful information on the subject of steam, perhaps more than is to be found combined in any other volume of its size, although we do not think it does full justice to its title, particularly in what regards Steam Navigation, as we have already observed.

ON WIERS OR DAMS ON RIVERS.

Observations on the Effect produced by erecting Weirs or Dams on Rivers, and on their efficacy for Navigation Purposes.

By William Bull, Civil Engineer.

Weirs are generally erected either for the purpose of raising a head of water for the use of mills, or for the purpose of navigating the channel of a river, and they cause in the first instance a permanent elevation of the ordinary surface of the water.

If a weir has the same length of top surface as the section of the river at the place where it is erected, it will cause such flood waters as would have been retained within the natural banks of the river, before it was erected, to rise above them in proportion to its height, and overflow the adjoining lands if artificial embankments of proportional height are not erected to prevent it.

When more water comes down the river than its banks could have previously held, then, although the weir causes an increase of height, the evil is less in proportion than in the former case.

In extreme floods, when the water would rise far above the surface of the valley, the small increase of height caused by the weir is of little or no consequence, as other causes generally exist, such as embanked roads leading to bridges, and the contraction of the stream by the bridges which obviates the effect of the weirs; unless the latter be situate at or close to the bridge.

Weirs cause the beds of rivers to rise by retaining the sand and gravel brought down by the stream, with much more rapidity than the adjoining lands rise from the deposit of lighter silt first in the upper portions of the rivers where they are erected, and ultimately throughout their course as far as the weirs extend, by which the sectional area of the rivers is diminished and of course the land adjoining rendered more subject to floods.

This is an evil that may be partially remedied by dredging and embanking. I say partially, because, from the manner in which the former is usually done, (*i. e.* only with a view to keep open a narrow channel in the river for the use of boats,) it has very little tendency to produce it, and if done to the whole extent of the river, would become a very expensive operation, and the latter, even when well executed at first, being constantly liable to delapidation, is for ever subjecting the lands to inundation. This is particularly illustrated in Holland, where the rivers, having been dammed up and embanked, have been permanently elevated above the adjoining lands, and where destructive inundations are by no means of rare occurrence.

Where no weirs exist, rivers have generally a tendency to deepen their beds (particularly if the water is confined to a channel of moderate width) from their source to their confluence with the sea, or until they arrive at an estuary or low flat track of land, when the sand and gravel or other material driven or borne down by the water, is either deposited in such estuaries or on bars at the river mouths, or is dispersed along the shores of the sea by the tidal wave.

I have observed many instances of the gradual lowering of the beds of rivers, but more particularly one which has recently come under my observation, where the out-fall of a mill-goit has been lowered two feet in about four years. This phenomenon is, of course, most obvious where the fall in the river is greatest, all other circumstances being equal.

By making a weir of greater length than the general section of the river, and by widening the river above and below the same, a part of the injury to adjoining lands by raising the surface of the water may certainly be avoided, so long as the river is continued of the increased width, and by extending the length of the weir and the widening of the river to a great or almost indefinite extent, both in line of the current as well as in width, the injury to adjoining lands may be nearly if not entirely obviated for a limited time, but it can only be for a limited time without constant care and attention, and a considerable periodical outlay, (much more of each than is usual or likely to be devoted to such purpose,) because, from the surface of the water being extended, the stream will become proportionally sluggish, particularly towards one or both sides, where, as well as in the natural bed of the river, the matter brought down by the stream will be deposited, and the river will again assume its original width or nearly so, and render the increased length of the weir of little or no avail. The time which will expire before the river assumes its original width will depend materially on the quantity of matter held in suspension by the water, or driven forward by the impetus of the stream, and on the velocity of the stream above and at the point where the weir is erected.

In such instances as where, for some distance before arriving at the weir, the fall and consequent velocity of the stream is of a moderate degree, and where the upper surface of the river has been enlarged, and thereby the velocity of the current diminished, there being only a light alluvial matter and sand held in suspension, or driven forward by the stream, such matter will be rapidly deposited on the sides of the river, until the sectional area is again so contracted as to increase the rapidity of the current to its original rate.

If, instead of the fall and velocity being of that moderate degree which will only carry forward the lighter matter, it is of such a degree as to force down gravel and other heavy matter, the length of the pond first caused by the erection of the weir will be gradually diminished, until the whole of the original bed of the river is filled up to the weir, so as to form the inclination of the new bed at nearly the same angle as it was before the weir was erected; but in this case the contraction of the stream to its original width will go on much more slowly than in the former case, arising from the filling up of the bed, causing the velocity of the stream to be reduced in a less ratio than it would have been if the heavier matter had not been brought down into the original bed of the river.

If the bed of the river is constantly dredged, so as to keep it of its original depth to the upper end of the pond formed by the weir, then the top surface will contract much more rapidly than in the last case, until it arrives at or approximates to its former width, as in the first case by reason of the heavy material being prevented by the dredging from raising the body of the stream so much as it would have done had no dredging been used, and the consequent less velocity of the stream allowing the lighter matter to be deposited at the sides.

From the foregoing observations it will follow that the increased length of the weir, and accompanying width of the river beyond its former dimensions, renders but a partial and temporary advantage, in diminishing the damage to adjoining lands arising from the erection of such weir, and that such erection, whether of greater length than the section of the river or not, does not in itself provide a permanent means of navigation.

Many instances of the inadequacy of weirs for supplying a permanent means of navigating natural rivers may, I have no doubt, be adduced. In the instance of the Calder and Hebble navigation, where I have been practically acquainted with the subject for the last eight years, they are abundantly manifest, as well as in the adjoining navigation of the Aire and Calder, with which I am well acquainted, the proprietors of both of which have been for many years adopting means to avoid the natural stream by substituting cuts or canals.

When first the River Calder was made navigable, it was divided into pools by weirs of sufficient height to give the required depth of water and these weirs were passed by means of locks; but it was soon found that the matter brought down by the stream was rapidly filling up the pools, and consequently diminishing the depth of water, whereby the navigation was much impeded; this was first most ap-

parent at the upper ends of the pools, where the heavy materials, such as gravel and boulders, were first deposited on coming in contact with the comparatively still water produced by the weirs, and as the stream advanced, by deposit of the sand and lighter materials further down. At first recourse was had to remedy the evil by raising the weirs by means of boards, which were frequently washed away by the floods, and had to be renewed as the water subsided, and partly by raking the gravel and sand to the sides of the river. But as soon as the power of the dredging engine became known, recourse was had to it; it was, however, still found that although they had procured and kept in constant work two of these engines, the deposit was gaining on them; they therefore had recourse to the adoption of canals, as before stated, commencing with those parts which were the most affected by the deposit, until they now use only a little more than four miles out of a distance of twenty-two miles of the river. The Aire and Calder Company now use about nineteen miles out of forty-three, by having recourse to dredging, and raising their weirs by means of boards, as before described. That they, are enabled at present to navigate a greater proportion of the rivers than their neighbours, no doubt arises principally from the circumstance of their being situated further down the stream, and their being numerous weirs above, which retain the sand and gravel from coming down to them.

I cannot conclude these remarks better than by giving the result of my observation and experience, which is that converting natural rivers into artificial navigations by erecting dams across them, is much to be deprecated. First, because the dams cause the adjoining lands to be more frequently overflowed than they otherwise would be. Secondly, because dams obstruct the ordinary drainage of the country. Thirdly, because the object sought is but imperfectly obtained, and lastly, because it is the means of materially retarding, if not of entirely preventing, the adoption of the more efficient means of providing for inland navigation by artificial canals, which, if made at all, are rarely or never made so complete as they would have been had no attempt been made to adapt the natural rivers.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF CIVIL ENGINEERS.

March 9.—The PRESIDENT in the Chair.

"*Description of the Arched Timber Viaducts on the Newcastle and North Shields Railway, erected from the designs of Messrs. John and Benjamin Green; and on the application of the same system of construction to oblique and other Bridges, to the Roofs of Railway Stations, and to other large Buildings.*" By Benjamin Green.

The construction of viaducts and bridges forms so important an item in the cost of a railway, that the engineer is induced to devise new methods of completing his works with due regard to stability and durability, and at the same time with the least possible expense. Stone and brick have been the materials most generally used for bridges; cast iron has been introduced where the heights were too low for the spans, in large arches, or in trussed beams where a certain clear space beneath was required, with only a limited height to the level of the rail. Timber, from its lightness, strength, and cheapness, has been extensively used, but only in spans of limited extent, owing to the sole mode of its application being by framed trusses, upon the same principles as those usually employed for roofing.

These considerations induced Mr. John Green, as far back as the year 1827, to make a design and model for a bridge, with timber arches resting upon stone piers. In 1833 the plan was adopted, and in 1837 it was put into execution at the Ouse Burn Viaduct, where the construction was of great extent, and the cost was an important consideration.

The Viaduct is 918 feet in length, and 108 feet in height from the bed of the river. There are five arches, the versed sine 33 feet, and the radius 68 feet; three of them are 116 feet span each, and two are 114 feet each: two stone arches of 40 feet span each have been introduced at each end to give length to the abutments, and to prevent the embankments from being brought too near to the steep sides of the ravine. The piers are of stone: the springing stones for the three ribs, of which each arch is composed, are on offsets, within 40 feet of the top of the piers; cast-iron sockets are there bedded in the masonry, and secured so as to receive the feet of the ribs. Two of the piers are placed upon piles; the others are founded upon the rock: immediately beneath the centre of one of them an old coal-pit shaft was discovered, and close adjoining to it the remains of the working of a coal seam: both were rendered secure by being filled up with grouted rubble masonry.

The ribs for the arches are composed of planks of Dantzic deal (Kyanized): the lengths vary from 46 feet to 20 feet, by 11 inches wide and 3 inches thick: they are so disposed, as that the first course of the rib is two whole deals in width, the next is one whole and two half deals, crossing the joints longitudinally as well as in the depth. Each rib consists of fourteen deals in thickness, bent over a centre to the required form, and secured together by oak treenails 1½ inch diameter at intervals of 4 feet apart, each treenail traversing three of the deals. A layer of strong brown paper dipped in boiling tar is placed between the joints, to bed them and exclude the wet. Trussed framings and beams are secured upon the arched ribs; the platform composed of planks, each 11 inches wide by 3 inches thick, is spiked down and covered with a composition of boiling tar and lime mixed with gravel in laying on, forming a coating impervious to the wet; upon this platform the two lines of railway are laid, leaving a foot-path between them.

The centreing for turning the ribs was very light and simple, and as every convenience was afforded by having a railway with travelling cranes along the sides of the piers, a whole centre could be moved by twenty men from one arch, and fixed in another in one day.

The author then describes the construction of the Wellington Viaduct, and that which has been erected by him at Dalkeith for the Duke of Buccleuch; giving the relative costs of the three structures which have been mentioned, and stone buildings of the same dimensions: whence it appears that in the Ouse Burn Viaduct there was an economy of £9000, resulting from the adoption of this system.

He then shows the application of this system to the structure of oblique bridges, particularly where a certain clear space is required beneath, and the total height is limited: this is illustrated by a description of a bridge of 71 feet span, on the Newcastle and North Shields Railway, which crosses the turnpike road at Walker, and by one erected over the River Wear on the West Durham Railway.

He describes also the application of the same system to the extensive buildings and sheds of the Shields Railway Station; to churches and to private houses; in the latter the arched form is very advantageous in gaining space for the upper rooms, showing at the same time the economy resulting from the adoption.

The paper is illustrated by a series of nine elaborate detailed drawings, showing the application to every kind of construction.

Mr. Rendel remarked, that on those railways where first cost was a matter of importance, the introduction of a superior kind of Timber Bridge was a great desideratum. The communication proposed the application of tarred paper between the joints, from experience he could not recommend either paper or felt in such situations. He found that both substances prevented the intimate contact of the surfaces of the timber; in all framings exposed to the action of the weather the tar was absorbed by the wood; the paper and felt then became saturated with and retained the moisture, so that decay very speedily ensued. The mode he at present adopted was to have all the joints and mortices of the framings very closely fitted, leaving only sufficient space at the edges to be caulked with oakum, and the joint run with pitch, like the seams of the deck of a vessel. Wherever it was practicable, great advantage would result from covering the joints with sheet lead, to exclude the moisture and prevent the decay, which was the great bar to the more general use of timber in many engineering works.

Mr. Vignoles was inclined to think the curve of the arch was too steep; he should prefer its being flatter. He would not then enter into the subject, but he would present to the Institution a large model of a Timber Bridge, and with it a communication, explaining his views on this subject, which was one to which he had paid much attention.

Mr. Macneil had found constant trouble to result from the decay of wooden bridges. The Dalmarnoch Bridge, which had been erected about thirty years, now demanded continual repairs; the struts were nearly all decayed at the points of insertion into the cast-iron sockets. The original floor had been replaced by one of teak wood.

In answer to a question from the President as to the process of "Kyanizing" timber for the Hull and Selby Railway, Mr. Timperley described the method pursued there. In a close cylindrical wrought-iron vessel, 70 feet long and 6 feet diameter, filled with a solution of corrosive sublimate, the timber was piled, leaving a space along each piece: the air was then exhausted by air-pumps to a vacuum of about 25 inches by the mercury gauge, and by the application of a force-pump, under a pressure of 100 lb. per square inch, the solution was driven into the pores of the timber. From experiments he had made he believed that the timber was thus thoroughly saturated, and although sufficient time had not elapsed to give any correct result as to the comparative duration of the sleepers, he thought very favourably of the process.

The original cost of the timber, which was the best Riga Balk, squared, was 5*l.* 10*s.* per load (50 cubic feet). The expense of "Kyanizing" about 400,000 cubic feet, including the interest of the first cost of the apparatus, was between fourpence and fivepence per cubic foot. The process was carried on with greater rapidity, and much more effectually, than it could have been done in open tanks.

Mr. Lowe was of opinion, that although the mechanical part of this process appeared very effective, it was not really so. There were chemical difficulties: a certain length of time was required to dilute and extract the sap and aqueous matter from the pores. The greater or less duration of the process might in some measure account for the difference of the results practically obtained. Dry planks succeeded better than wet ones; with sound dry timber any solution of the metallic salts, such as the sulphates of iron or copper, was efficacious, but with wet timber he doubted whether any preparation would be effectual.

Mr. Cooper believed that in the process of "Kyanizing" the chlorine united with the albumen, and formed chloride of albumen; it was possible that in the exhausting process the air contained in the timber would expand and

prevent the capillary tubes from becoming perfectly saturated with the solution of corrosive sublimate.

March 16.—The President in the Chair.

John Hambley Humfrey was elected an Associate.

"*Description of the Methods adopted for raising and sustaining the sunken Roof of St. George's Church, Dublin.*" By Robert Mallet, Assoc. Inst. C. E.

St. George's parish Church, one of the finest ecclesiastical edifices in the city of Dublin, was completed in the year 1802, from the designs of the late Francis Johnston, Architect to the Board of Works at that time, at a cost of about £90,000.

The church had not been built many years, before the roof, which was covered with tun slating and copper, gradually sunk in several places, by which the cornices at the flank wall were pushed several inches outward. The subsidence slowly but continually increased. The ceiling cracked in various places, the ornamental stucco work began to drop off, and in the year 1836 the state of the roof was such, that the church was deemed unsafe for use, and was shut up.

Messrs. John and Robert Mallet were consulted as to the practicability of restoring the roof. In November, 1836, they reported that they considered the ceiling might be preserved, and described the manner in which they proposed to accomplish it.

The mode proposed consisted in interweaving with and adapting to the timber framing of the roof, a system of metallic framing, so arranged, that all strain or stress should be removed from the former, and borne by the latter, as well as removing all lateral pressure from the walls of the building.

A careful survey of the roof showed that the ends of several of the principals were unsound. A small hole was then bored through the ceiling, close to each queen-post, and a deal rod, ½ an inch square, dropped through each. These rods were all of equal length, and their upper ends were secured level with the top surface of the tye-beam of each principal; then with a levelling instrument placed in the gallery, observations were taken, and the exact amount of the deflection of the framing ascertained. The variation was considerable, but the greatest amount of depression was found to be 5¼ inches. The whole roof was strained and distorted, and was so unsafe that the slightest effort caused vibration throughout.

The causes of this failure appeared to be threefold: a radical want of strength in the framing of the roof; secondly, the employment of unfit tyebeams, which having been constructed during the Continental war, when timber was scarce and dear, were formed almost wholly of short lengths, averaging not more than 20 feet, lapped and scarfed; thirdly, in the queenposts having been badly constructed and ill placed.

The stone corbels, which supported the oak cantilevers, being originally cut almost through to receive the wall-plate, were nearly all broken in the middle. It was proposed, therefore, to remove the oak cantilevers and stone corbels, and to cut away the timber wall-plate beneath each principal, to level up the wall, placing a suitable cast-iron abutment piece at each end, and to spring from side to side a cast-iron arch, in "double flitches," connected through the spaces of the timber framing by hollow distance pieces, and also by a certain number of equidistant cross-heads, from which should drop down vertical suspending rods, capable of being adjusted in length, and connected with the tye-beam of the principal, so that being drawn up straight, and the respective parts secured, the weight of the whole roof would be transferred through the framing to the tye-beams; whilst they being hung from the system of suspension rods of the cast-iron arches, which would thus sustain the whole load, and their abutments being held together by the tye-bars in the chord line, the load would bear vertically upon the walls.

It was then determined to raise the roof and ceiling by forces applied from below; to cut away the rotten ends of the principals and to reconnect them with the walls by a modification of the cantilever bracket, invented by Mr. Alfred Ainger, and described in the Transactions of the Society of Arts (vol. 42): The whole of the oak cantilevers and stone corbels were to be removed as useless incumbrances.

The total weight of the roof being about 133 tons, each framed principal would sustain about 16½ tons, and each vertical suspending rod about 1¼ ton.

Although the weight of material in this roof and ceiling may be considered uniformly distributed, it was impossible to foresee what change might be effected in the framing by forcing the ceiling and roof up to a level line, or what amount of force might bear upon particular points, from the elasticity of the materials being thus forcibly constrained. It hence became a matter of prudence to provide in all parts a large surplus of strength, bearing in mind that, in any complete system, "the strength of the whole is limited by that of the weakest part, and thus that partial strength becomes total weakness." The dimensions of the scantling were accordingly so calculated that the utmost strain upon it should not exceed 4·5 tons per square inch, considering 9 tons to be the practical limit to which wrought iron might be exposed.

After giving the formulæ for calculating the strains upon the different parts of the roof, with the reasons why the theoretical dimensions were in some instances departed from, the author apologises for entering so much into detail of the construction, quoting at the same time the writings of Smeaton and Telford, as abounding in the richest details of theoretic deduction, modified by practical judgment. He then proceeds to describe the means adopted.

Immediately beneath each of the fourteen queen-posts of the roof, an aperture of 30 inches square was cut through the floor of the church, and a piece of brick and cement built up from the arches of the vaults beneath to the level of the floor; on the top of each, a plate of cast iron was bedded, and upon each plate a block of oak timber about 4 inches thick.

Fourteen straight whole balks of Memel timber, each 3 feet shorter than the height of the church between the floor and the ceiling, with their extremities cut square and smooth, were placed vertically upon the blocks; upon this level a platform was laid; across the tops of the vertical balks, pieces of oak scantling were placed; fourteen powerful screw-jacks were then fixed, one beneath each queen-post, and the ceiling cut away for the points to bear directly upon the beams.

During the progress of these operations, the whole of the ceiling and roof framing had been carefully examined. The dust was removed from the joints and open mortices, &c., of the framing, and the cracks in the ceiling were cleared out by passing a fine whip saw through them, so as to permit their closing when the ceiling was raised to a plane surface.

The preparations being completed, the word was given to heave simultaneously upon the screw-jacks: the roof rose slowly and steadily, and as soon as any one of the small deal standard rods had reached the level plane, the motion of the screw-jack at that spot was stopped. In about two hours, the whole roof, together with the ceiling, was brought up level, without any accident or injury to any portion of the ceiling. The cracks in the latter as well as the joints and mortices of the framing were found to be nearly all closed. Some slates were broken, and the copper of the platform, which before was wrinkled and loose, was now found to be drawn tight over the timber sheathing.

The roof being thus supported from beneath, the masonry was cut out round the ends of the principals; the oak cantilevers and corbels of granite, and the rotten ends of the timbers, within a few inches of the inside face of the walls, were also removed.

The cantilever and abutment castings were now applied and bedded with lead and oil putty, on blocks of stone set at the level of the under side of the tye-beams, on footings of brick and cement. The chord bars were next placed, and temporarily adjusted by means of their screw nuts. The arch segments were put up in succession, their centre or key pieces bolted in, and the segments adjusted to them by means of wedges of African oak: the suspending rods were then hung on from the top shackles, and the junction made good with the tye-beams, by means of the lower cross-heads, stirrups, and shackles.

As soon as the whole system of the seven arched frames was complete, and the cantilevers adjusted to the ends of the decayed timbers, standing lengths of pine rods were placed in right lines from centre to centre of each pair of abutment cross bolts, and all the chord bars and suspending rods were brought up by means of their adjustment screws, until the united effort of the whole system had lifted and supported the entire roof and ceiling from the screw-jacks, on which they had previously rested, so that these latter all became loose.

The whole was now left quiet for some days, in order that every part might take its bearing, and that the sufficiency of the structure should be proved before the final removal of the screw-jacks, &c., which remained within about ⅛ of an inch of the blocks beneath the tye-beams, by which means, in case of accident, the amount of fall would have been limited to that small distance. The entire work, including the repairing the cracks in the ceiling, occupied little more than four months, and has never since required either alteration or repair.

The total amount of the contract for this work was 1362*l.* 6*s.* The repair of the injury done to the ceiling only amounted to 33*l.* 0*s.* 8*d.*, and the damage done to the slating, platform, flooring, &c., did not amount to more than an equal sum.

The total amount of cast and wrought iron in the structure was 21 tons 10 cwt. 2 qrs. 19 lb.

The communication is illustrated by five elaborate drawings on a large scale, showing the general arrangement and modes of proceeding, and also the details of the construction of the roof and of the cast and wrought-iron works used in the repairs.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

July 5.—Earl de Grey, President, in the Chair.

A paper was read by Professor Willis, of Cambridge, Hon. Mem. F.R.S. &c., *On the construction of the Vaulting of the Middle Ages.*

The vaulting of the Gothic architects differs essentially from that both of ancient and modern times, inasmuch as it consists of a combination of ribs, each forming an independent arch, both laterally and diagonally, with the intermediate spaces filled in upon the extrados of the arches to form the spandrils, whereas, according to the ordinary system of vaulting, the whole is solid and keyed together. The principles of this latter mode of construction were first developed by Philibert de l'Orme, who, in his celebrated treatise, lays down the rules for drawing the vaults and setting out the voussoirs—but of the practice of the Gothic architects we have no account, and it remains to be inferred from an examination of their works. That they proceeded by geometrical methods there can be no doubt, though they were probably extremely simple, differing greatly in that respect from those expounded by Philibert de l'Orme. One thing to be especially observed in the